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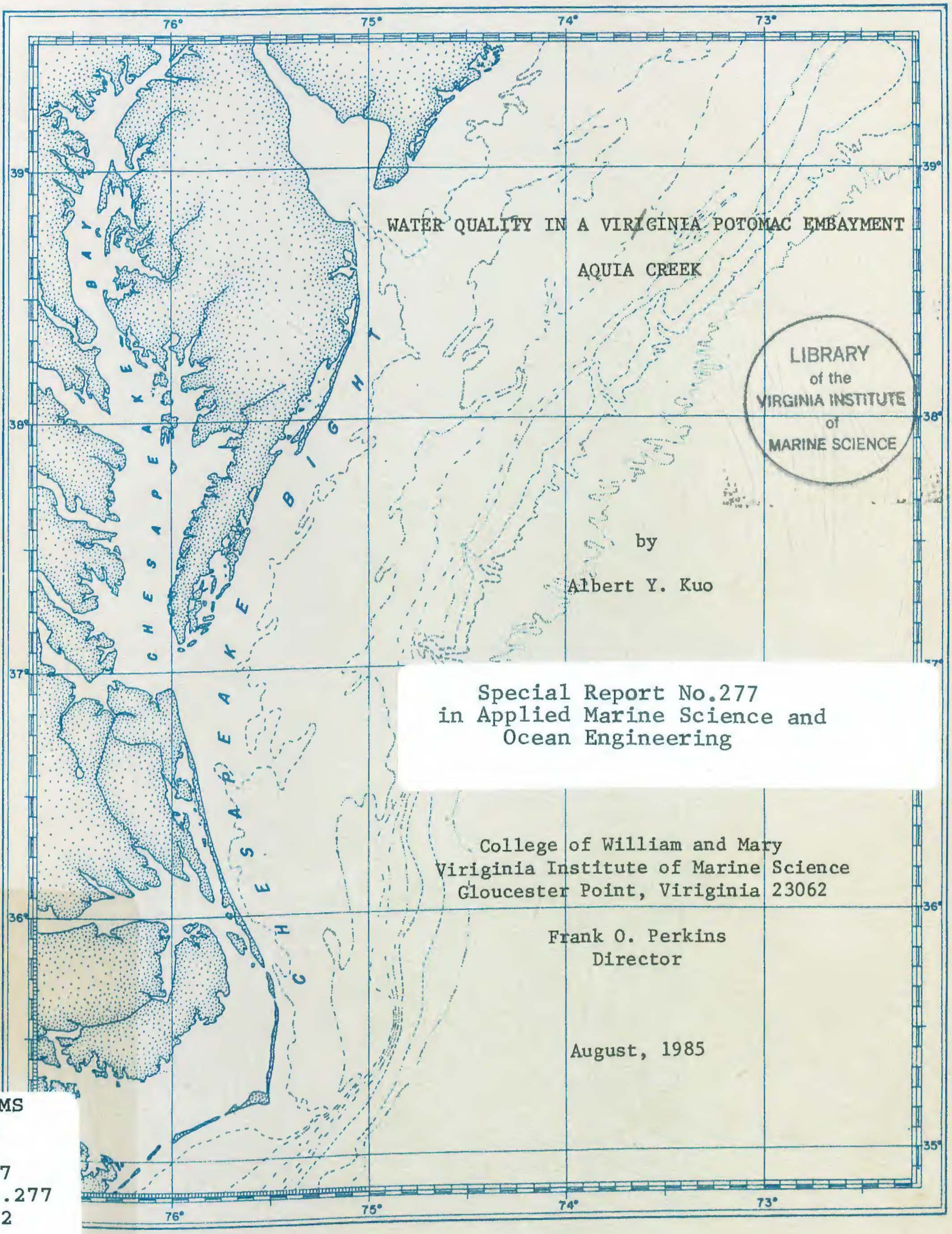

WATER QUALITY IN A VIRIGINIA POTOMAC EMBAYMENT

AQUIA CREEK

by

Albert Y. Kuo

Special Report No.277
in Applied Marine Science and
Ocean Engineering

College of William and Mary
Viriginia Institute of Marine Science
Gloucester Point, Viriginia 23062

Frank O. Perkins
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CHAPTER I. SUMMARY

The Aquia Creek study had three primary objectives:

1) To collect comprehensive field data suitable to characterize the system and for use in calibrating and verifying a mathematical water-quality model.
2) To calibrate and verify a mathematical model suitable for use in determining the factors which influence water quality in the system and for use as a management tool.
3) To employ the model and the data in an examination of the determinants of water quality, especially the algal population.

The fulfillment of the objectives and the results of the study are summarized below.

Water-quality surveys were conducted in the summer of 1981. Sampling included a series of slackwater surveys conducted from May through September and an intensive survey conducted in August. Two supplemental slackwater surveys were conducted in July and August, 1982. The water-quality surveys were supplemented by measures of bathymetry, tide, current, and benthic nutrient and oxygen fluxes.

Two primary indicators of water quality are the algal population, quantified as the chlorophyll 'a' concentration, and the dissolved oxygen concentration. Chlorophyll concentrations in the 10-30 µg/l range were commonly observed in Aquia Creek and the maximum chlorophyll observation was less than 40 µg/l. Observed dissolved oxygen concentrations were usually around 7-8 mg/l. Minimum dissolved oxygen observation was as low as 2.5 mg/l.

A one-dimensional, real-time model has been applied to the system along the axis of the creek. The model consists of hydrodynamic and water-quality submodels. The hydrodynamic submodel provides predictions of surface level, velocity and dispersion to the water-quality submodel which treats organic nitrogen, ammonia nitrogen, nitrite-nitrate nitrogen, organic phosphorus, ortho phosphorus, chlorophyll ′a′, CBOD, and dissolved oxygen.

The model has been calibrated and verified against data derived from the August, 1981 intensive survey, and the June-August, 1981 slackwater surveys. The model is suitable for use as a management tool.

During the survey conducted for this study, chlorophyll growth was largely limited by the availability of nutrients, particularly inorganic nitrogen. Observed concentrations of inorganic nitrogen were generally at or near the level of laboratory detection limit. Reducing the phosphorus input from point source may further limit the algal growth in the upstream section of the creek.

Benthic fluxes of ammonia and nitrate nitrogen, ortho phosphorus, and oxygen were measured in two instances in 1981 and 1982. The benthic release of ammonia nitrogen plays a significant role. It supports about 50% of algal population in the creek during the model calibration period of August, 1981.

The tidal portion of the Aquia Creek may be divided into two distinct sections. One is a wide and straight embayment downstream of kilometer 7 at which the creek undergoes an abrupt geometric change. The other is a narrow and meandering creek upstream of the geometric change. The water quality conditions in the wide embayment are dominated by the inputs from the Potomac River. The narrow creek is influenced by the point source discharges, the nonpoint source runoff, and also by the input from the Potomac River. Occasionally, the effect of high nonpoint runoff may be felt in the wide embayment.

CHAPTER II. INTRODUCTION

This Aquia Creek investigation is part of a larger Potomac Embayments Study initiated in 1979 to survey and model a series of Virginia embayments tributary to the upper, tidal portion of the Potomac River. Prior to the study, these embayments were reported to be subject to nuisance algal blooms and accompanying undesirable dissolved oxygen fluctuations. The purpose of the study is to collect comprehensive, consistent field data describing the conditions in these embayments and to provide mathematical models which can be used both to analyze the factors which contribute to the problems in the embayments and to evaluate alternative management strategies to alleviate the undesirable conditions.

A. Description of the Aquia Creek

The Aquia Creek is located on the Virginia side of the Potomac River approximately 61 km downstream of Washington, D. C. The creek has a drainage area of about 225 km^2, including a reservoir located 3 km upstream of tidal limit. The drainage basin is largely wooded but also has extensive amounts of residential and commercial development. Topographically it tends to be fairly hilly, with elevations as great as 70 m in close proximity to the tidal creek.

The tidal portion of the creek extends about 13.5 km from the mouth (Fig. 2-1). The upper half of the creek is relatively narrow, with width less than 50 m. There is a sudden expansion at 6.8 km from the mouth. The lower half of the tidal creek has widths ranging from 500 m to 1500 m. The depths throughout the creek are shallow and of the

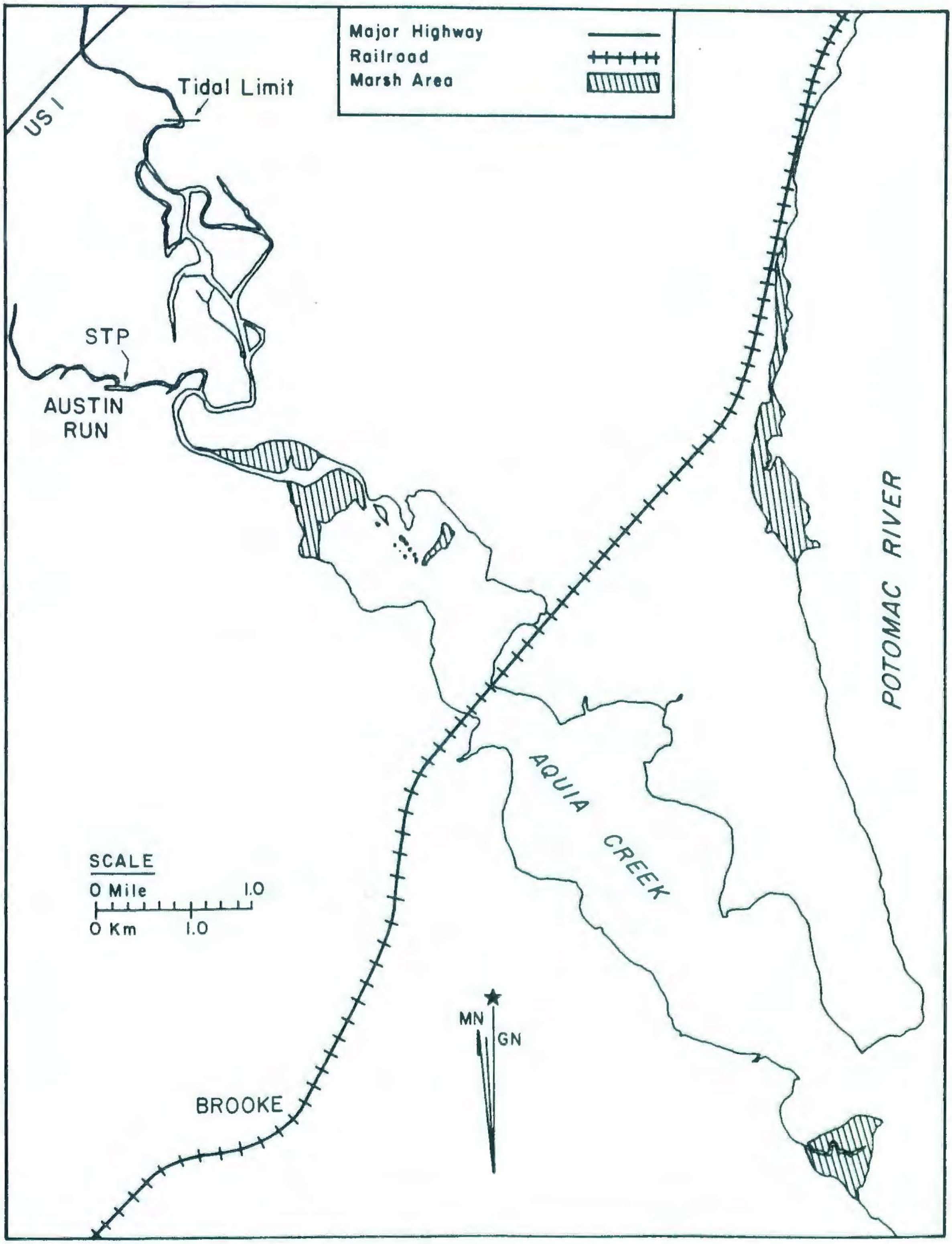


Figure 2-1. Aquia Creek.

order of 1-2 meters. The tide range at the mouth averages 40 cm and increases slightly (approximately 15%) upstream. The water is fresh throughout and has tidal currents on the order of 10 cm/s or less. Dry-weather flows in the tributary creeks are small, 0.3-1.0 cms (cubic meter/second), although these flows may increase by an order of magnitude or more subsequent to rainstorms.

Aquia STP (sewage treatment plant) is the only point source discharging into the Aquia Creek system. The STP discharges an average flow of 0.038 m^3/s (0.86 mgd) into the Austin Run, a small tributary of the Aquia.

B. Objectives of this Study

There are three primary objectives to this study. The first is to collect a comprehensive and consistent set of field data describing the conditions in Aquia Creek. The second is to calibrate and verify a mathematical model of water quality in the Creek. The third is to use the mathematical model to investigate those factors which primarily determine water quality within the creek. The fulfillment of these objectives is described in the remaining chapters of this report.

CHAPTER III. THE FIELD PROGRAM

Field data for this study were collected during the summer season of 1981 and include hydrographic data, water quality data, and special-purpose data. Two supplemental slackwater surveys were also conducted in the summer of 1982.

A. Hydrographic Surveys

The hydrographic data collected during this study include measures of tidal height and current velocity within the creek. The locations of the tide gauge and current meters are shown in Figure 3-1. The tide gauge at the mouth of the creek was maintained for two and one-half months, mid-June to early September. In addition, four tide staffs were monitored during the intensive field survey of August 24-25, 1981. Two current meters were installed from August 22 through August 25. Typical portions of the tide and current records are displayed in Figure 5-3, in which they are compared with model predictions.

B. Intensive Survey

The intensive survey is a water-quality survey conducted over a period of two tidal cycles, approximately 26 hours. The purpose of the survey is to monitor, as closely as possible, the inputs to the creek and the water quality within the creek. The survey is conducted for 25 hours so that both the intratidal and diurnal behavior of the embayment may be noted.

The intensive survey was conducted from 1300 hrs. August 24 to 1500 hrs. August 25. Samples were collected from mid-depth at the nine

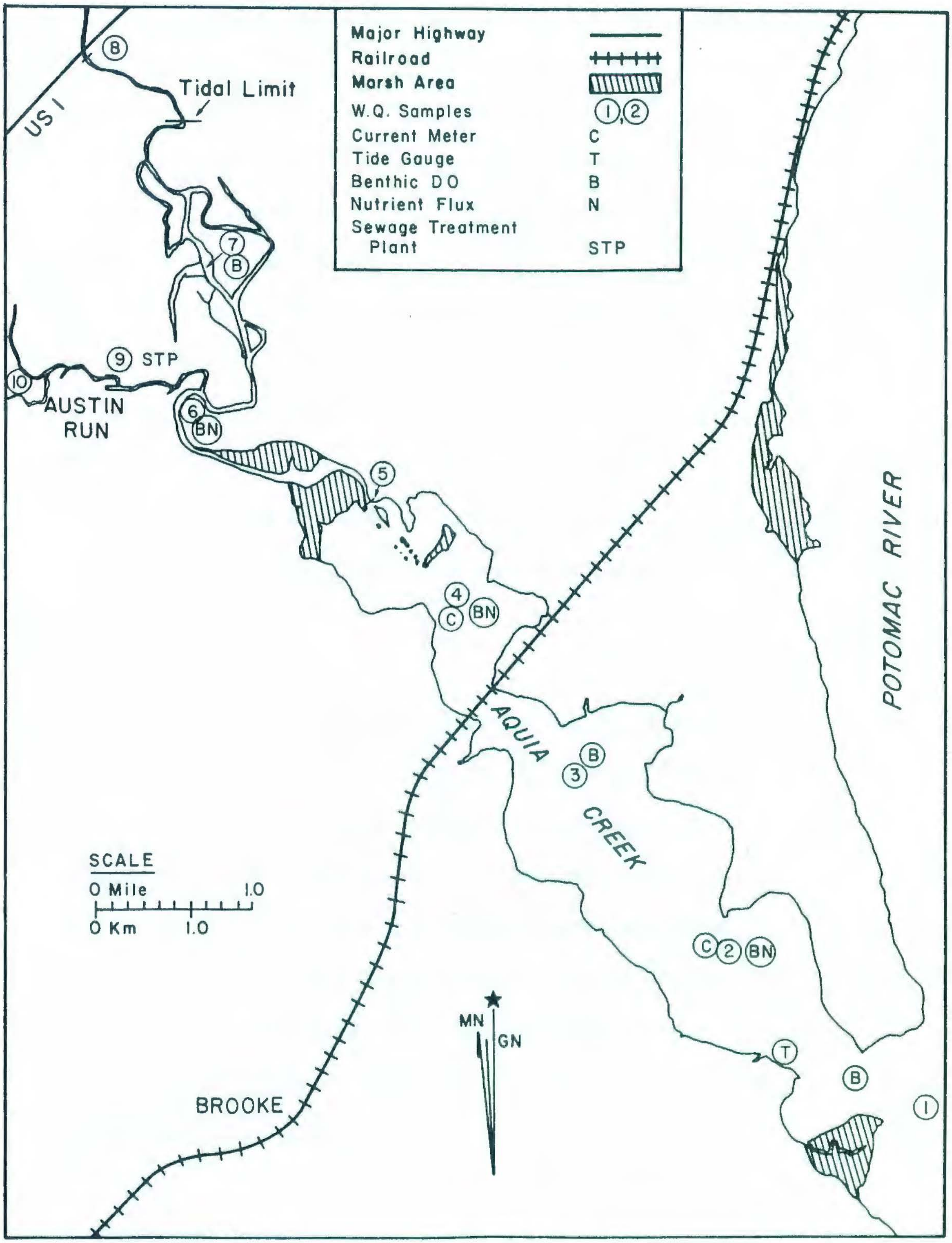


Figure 3-1. Sampling stations.

instream stations shown in Figure 3-1. The parameters sampled and the sample interval are presented in Table 3-1. Dissolved oxygen (D.O.) was measured in situ with a Yellow Springs Instruments probe. Nitrogen, phosphorus, and BOD samples were iced and delivered within 24 hrs. to the Commonwealth of Virginia Consolidated Laboratories for analysis. Chlorophyll samples were frozen for subsequent analysis at the Virginia Institute of Marine Science.

In order to measure the inputs to the Aquia Creek system, the Aquia STP effluent also was monitored. Prior to and during the intensive survey, three twelve-hour composite samples were collected from the STP effluent (Sta. 9). The composites were analyzed for the parameters listed in Table 3-1 except that D.O. and temperature were sampled in situ rather than obtained from composites.

C. Dye Study

Concurrent with the intensive survey, a dye dispersion study was conducted in order to provide data for verification of the mass transport portion of the water quality model. During the six-hour period prior to commencement of the intensive survey, 9.06 kg of Rhodamine WT flourescent dye were continuously released at station 4 shown in Fig. 3-1. Dye samples were subsequently collected in seven sampling stations (Sta. 1 to 7) hourly during the intensive survey and in slackwater surveys conducted two, four, and six tidal cycles after completion of the intensive.

D. Slackwater Surveys

TABLE 3-1. Parameters and Sampling Interval - 1981 Intensive Survey (1300 Aug. 24 - 1500 Aug. 25)

Parameter	Interval
Total Kjeldahl Nitrogen	two hours
Ammonia Nitrogen	two hours
Nitrate + Nitrite Nitrogen	two hours
Total Phosphorus	two hours
Ortho Phosphorus	two hours
Chlorophyll ′a′	one hour
$CBOD_5$	two hours
pH	one hour
Temperature	one hour
Secchi Depth	one hour (daylight hours only)
Dissolved Oxygen	one hour
Total Organic Carbon	two hours
$CBOD_u$ (nitrogen inhibited)	three samples per station

TABLE 3-2. Dates of Slackwater Surveys

May 26, 1981	slack before ebb
June 11, 1981	slack before flood
June 23, 1981	slack before flood
July 7, 1981	slack before flood
July 23, 1981	slack before ebb
August 5, 1981	slack before ebb
September 21, 1981	slack before ebb
July 26, 1982	slack before ebb
August 12, 1982	slack before ebb

Slackwater surveys provide a near instantaneous view of water quality in the embayment during an interval of slack tidal current. A series of these surveys was conducted at approximately two-week intervals from late May through late September, 1981 (Table 3-2). Two additional slackwater surveys were conducted in 1982. Due to problems encountered in navigation, all surveys were conducted during periods of daylight hours. These surveys are less comprehensive than the intensive surveys, but provide valuable data for examination of long-term trends in water quality and for verification of the mathematical model.

The slackwater sample stations and sample parameters are the same as for the intensive survey (Fig. 3-1, Table 3-1). The STP effluent was sampled concurrently with each survey. During the majority of the surveys, flow in the streams (Stations 8 and 10) was gauged as well.

E. Special Purpose Surveys - Benthic Materials Flux

Measurements of the benthic fluxes of ammonia, nitrate, ortho phosphorus, and dissolved oxygen were conducted. Fluxes were measured at stations 2, 4 and 6 on August 24, 1981. The benthic D.O. flux was measured again at stations 2, 4, 5 and 6 in October, 1982.

Measurements were conducted by sealing a pair of hemispherical plastic domes to the creek bottom thereby entrapping a fixed volume of bottom water in each dome. By sampling the water within each dome periodically during the duration of the measurements, which lasted from four to eight hours, the rate of change of mass for each constituent within the dome was calculated. This rate of change of mass was then converted to an areal mass flux rate across the sediment-water interface.

F. Data Presentation and Conversion

All of the water quality data collected in 1981 and 1982 is presented in Appendix A. To allow comparison between the data and the model results, several of the parameters reported by the laboratory or collected in situ must be converted to a more useable form. The formulae used in these conversions are detailed below.

1) TKN to Organic Nitrogen - As analyzed by the laboratory, total Kjeldahl nitrogen includes ammonia nitrogen, dissolved and detrital organic nitrogen, and the nitrogenous portion of the algal biomass. To obtain organic nitrogen, as utilized by the model, the ammonia and algal fractions must be subtracted from the TKN via the following relationship.

$$\text{ORG N} = \text{TKN} - \text{NH}_4 - aN * \text{CH} \qquad (3\text{-}1)$$

in which

ORG N = organic nitrogen
TKN = total kjeldahl nitrogen of sample
NH_4 = ammonia nitrogen concentration of sample
CH = chlorophyll concentration of sample
aN = ratio of nitrogen to chlorophyll in algal biomass
= 0.007 mg/ g

2) Total Phosphorus - As analyzed by the laboratory, total phosphorus includes the phosphorus bound up in algal biomass. To obtain total phosphorus independent of the algal fraction, the following relationship is utilized

$$\text{TOT P (corrected)} = \text{TOT P (laboratory)} - aP * \text{CH} \qquad (3\text{-}2)$$

in which

TOT P = total phosphorus
aP = ratio of phosphorus to chlorophyll in algal biomass
= 0.001 mg/ g

The model further distinguishes between organic phosphorus and ortho phosphorus. Rather than convert the corrected values of total phosphorus to organic phosphorus, the model predictions of organic phosphorus and ortho phosphorus are summed, where appropriate, for comparison with field data.

3) $CBOD_5$ to $CBOD_u$ - The majority of the BOD analyses are nitrogen-inhibited five-day carbonaceous biochemical oxygen demand ($CBOD_5$). These must be scaled-up to ultimate carbonaceous biochemical oxygen demand ($CBOD_u$) and corrected for the respiration and decay of algae entrapped in the BOD bottle. The correction is accomplished through the relationship

$$CBOD_u = R * CBOD_5 - 2.67 * aC * CH \qquad (3-3)$$

in which

$CBOD_u$ = ultimate carbonaceous biochemical oxygen demand
$CBOD_5$ = five-day carbonaceous biochemical oxygen demand
R = ratio of $CBOD_u$ to $CBOD_5$
aC = ratio of carbon to chlorophyll in algal biomass
= 0.05 mg/µg

The ratio of $CBOD_u$ to $CBOD_5$ is obtained from the 25-30% of the slackwater and intensive survey samples which were analyzed for both five-day and ultimate CBOD. The ratios are listed in Table 3-3. Although the ratio varies both spatially and temporally, it is consistent, in an average sense, when samples from STP effluent are excluded. The average value, 2.57, of all the ratios from stations 1-7 is used to correct the $CBOD_5$ samples from these stations. Since all STP samples were analyzed for $CBOD_u$, no scale-up was required.

4) Disk Visibility to Light Extinction - The Secchi depth measured in situ must be converted to a light-extinction coefficient and further corrected for the extinction due to algae in the water column. The

TABLE 3-3. Ratio of $CBOD_u/CBOD_5$

Station	5/26	6/11	6/23	7/7	7/23	8/5	8/24	8/24	8/25	9/21	Average
1	1.81		3.02		2.60		3.13	2.58	2.73	2.33	2.60
2	1.97		2.80		2.40		2.60	2.60	2.50	2.24	2.44
3			2.41		2.60		2.11	3.25	2.85	1.96	2.53
4			2.75		2.54		2.52	2.73	2.64	1.98	2.53
5					2.70		2.99	2.89	2.51	2.92	2.80
6				2.49		2.31	3.50	2.69	2.91		2.78
7		2.21		2.29		2.48	2.41	2.33	2.42		2.36
8		2.81	3.31	3.13		2.00	3.63	2.84	2.94		2.95
10		2.44		1.67		2.38	2.51	2.57	2.76		2.39
9 STP	1.84	2.93		4.34	4.90	8.8	3.52	2.89	3.09	5.4	
Avg.											2.57*

*Average of stations 1 through 7

conversion and correction, obtained from Sverdrup et al. (1970) and Riley (1956), yield the equation

$$Ke = 170/DV - 0.0088 * CH - 0.054 * CH^{2/3} \qquad (3-4)$$

in which

Ke = light-extinction coefficient (1/meter)
DV = disk visibility (cm)

5) Presentation of Converted Data - The converted values of organic nitrogen, total phosphorus, and $CBOD_u$ are listed in Appendix B along with the unconverted values of those parameters necessary for comparison of model results with field data. The light-extinction coefficients are presented in subsequent chapters on model application.

G. Background Inputs

The volumetric and mass fluxes which enter the Aquia Creek through freeflowing portions of the creek are referred to as background or nonpoint-source inputs. These inputs were measured at stations 8 and 10 concurrently with the majority of the field surveys. In order to conduct long-term model simulations, and to analyze the total inputs to the system, however, information on the background fluxes between surveys is necessary. This information was provided, on a daily basis for the 1981 season, by the Northern Virginia Planning District Commission through employment of a nonpoint-source prediction model for the Aquia Creek drainage basins.

Time-series plots of the predicted daily inputs are presented in Appendix C. For comparison purposes, the instantaneous flux rates and chlorophyll and D.O. concentrations sampled concurrently with the field surveys are indicated on the same plots. The agreement between the predictions and observations is satisfactory except for the nitrite plus nitrate nitrogen and D.O. concentrations. The adjustment of these two parameters is discussed in the following chapter.

CHAPTER IV. DESCRIPTION OF THE MATHEMATICAL MODEL

The mathematical model employed in this study consists of two independent submodels, a hydrodynamic submodel and a water-quality submodel. The hydrodynamic submodel provides predictions of surface level and current velocity throughout the system and is also capable of predicting the transport of a conservative substance such as salt or dye. The water-quality submodel employs the hydrodynamic information provided by the first submodel to predict the concentrations of eight nonconservative dissolved substances: organic nitrogen, ammonia nitrogen, nitrite+nitrate nitrogen, organic phosphorus, ortho phosphorus, chlorophyll'a', carbonaceous biochemical oxygen demand, and dissolved oxygen. Both submodels are real-time and one-dimensional. That is, they predict parameter variations within a tidal cycle and along the longitudinal axis of the system, but not along the lateral or vertical axes. Details of the formulations of the models are presented in Williams and Kuo (1984). Brief summaries of the models are presented in the remainder of this chapter.

A. The Hydrodynamic Submodel

The hydrodynamic submodel is based upon the one-dimensional equations expressing the conservation of volume, momentum, and mass:

$$B \frac{\partial \eta}{\partial t} + \frac{\partial Q}{\partial x} = q \qquad (4\text{-}1)$$

$$\frac{\partial Q}{\partial t} + \frac{\partial}{\partial x} \left[\frac{Q^2}{A}\right] = -gA\frac{\partial \eta}{\partial x} - gn^2 \frac{Q}{A} \; Q \, R^{-4/3} + \frac{\tau_s}{\rho} B \qquad (4\text{-}2)$$

$$\frac{\partial}{\partial t} (AS) + \frac{\partial}{\partial x} (QS) = \frac{\partial}{\partial x} \left[EA \frac{\partial S}{\partial x}\right] + So \qquad (4\text{-}3)$$

in which
t = time,
x = distance along river axis,
B = the surface width of the river,
η = the surface elevation referenced to mean sea level,
Q = discharge,
q = lateral inflow,
A = cross-sectional area,
n = Manning friction coefficient,
R = hydraulic radius of the cross-section,
S = concentration of dissolved substance,
τ_s = the surface shear stress,
ρ = the density of water,
E = the dispersion coefficient,
So = source or sink of dissolved substance per unit length.

The governing equations are solved by dividing the continuum to which they apply into a series of finite segments. The volume, momentum, and mass equations are next integrated over the length of each segment resulting in a system of finite-difference approximations to the original differential equations. The finite-difference equations are integrated on a high-speed computer to provide predictions of surface level, velocity, and concentration.

B. The Water-Quality Submodel

The water-quality submodel provides predictions for eight dissolved substances which interact to form a simplified aquatic or marine ecosystem. Supplied with flow and volume information from the hydrodynamic submodel, the water-quality submodel operates by solving the finite-difference approximation to mass-conservation equation, eq. 4-3, with appropriate source and sink terms for each substance. The substances are organic nitrogen, ammonia nitrogen, nitrite-nitrate nitrogen, organic phosphorus, ortho phosphorus, chlorophyll'a', carbonaceous biochemical oxygen demand, and dissolved oxygen. The interactions among these substances, as accounted for in the model, are shown in Fig. 4-1. The source and sink terms, expressed for the longitudinally-integrated finite segments, are presented in the remainder of this chapter.

1) Phytoplankton (or chlorophyll'a') - The phytoplankton population, quantified as the concentration of chlorophyll 'a', occupies a central role in the schematic ecosystem of Fig. 4-1 and influences, to a greater or lesser extent, all of the remaining non-conservative dissolved constituents. The source/sink term for phytoplankton is expressed

$$SS = V * CH * (G-R-P-Ksch /h) + WCH \qquad (4-4)$$

in which

SS = mass source or sink in model segment
V = segment volume (m^3)
CH = chlorophyll 'a' concentration (μg/l)
G = growth rate of phytoplankton (1/day)
R = respiration rate of phytoplankton (1/day)
P = mortality rate due to predation and other factors (1/day)
Ksch = settling rate of phytoplankton (m/day)
h = local depth (m)
WCH = external loading of chlorophyll 'a' (mg/day)

Phytoplankton growth is dependent upon nutrient availability, ambient light, and temperature. The functional relationships used in

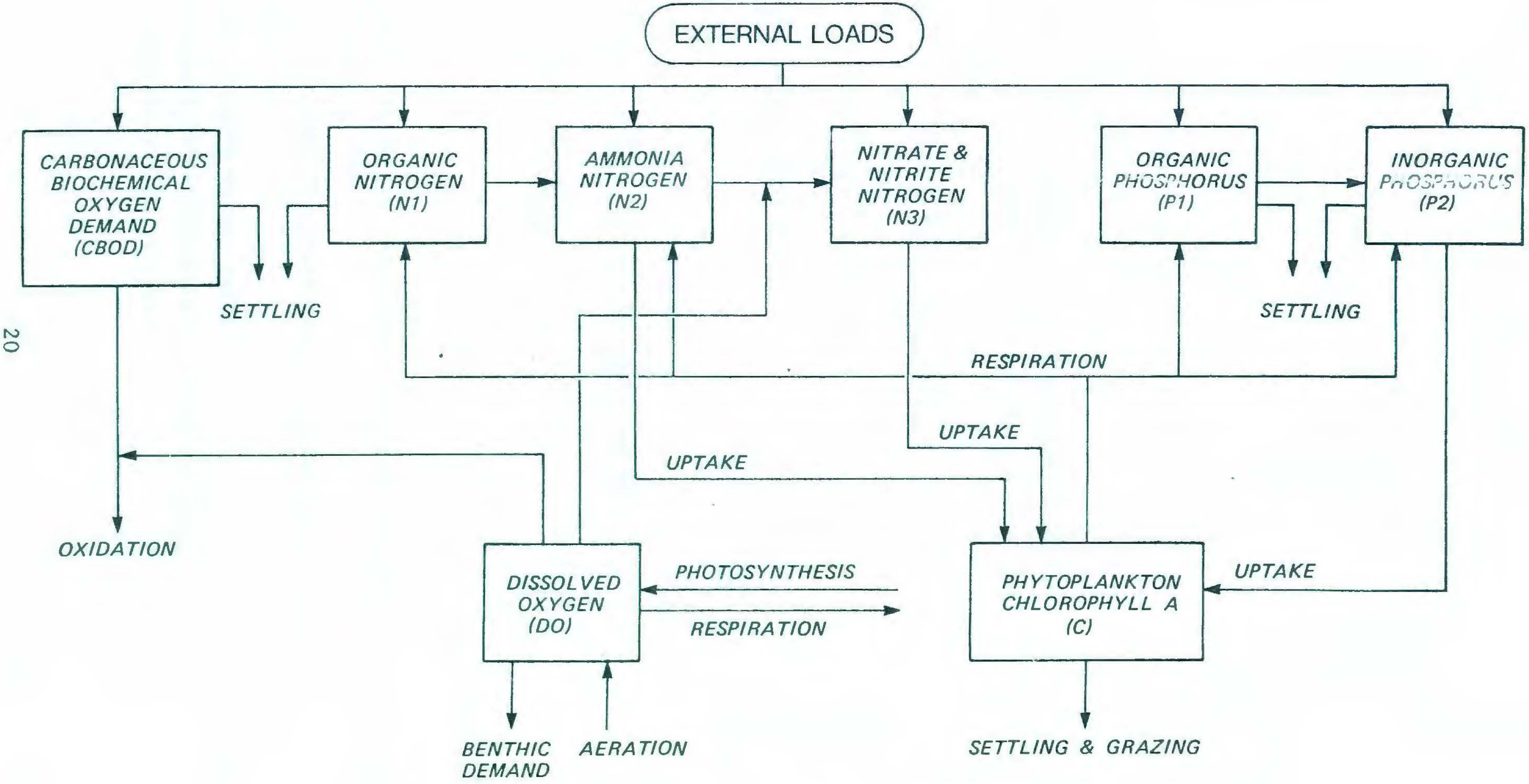


Figure 4-1. Schematic of ecosystem model.

the model generally follow the forms of DiToro, et al (1971) and are as follows:

$$G = Kgr * \underbrace{Tgr}_{\text{Temp. effect}} * \underbrace{I(Ia,Is,Ke,CH,h)}_{\text{Light effect}} * \underbrace{N(N2,N3,P2)}_{\text{Nutrient effect}} \qquad (4\text{-}5)$$

in which

Kgr = optimum growth rate at 20 C (1/day)

$Tgr = \theta gr^{T-20}$

T = temperature (C)

I = attenuation of growth due to suboptimal lighting

N = attenuation of growth due to nutrient limitations

$$I = \frac{2.718}{(Ke * h)} * [\exp(-\alpha_1) - \exp(-\alpha_0)] \qquad (4\text{-}6)$$

$$Ke = Ke' + 0.0088 * CH + 0.054 * CH^{0.66} \qquad (4\text{-}7)$$

$$\alpha_1 = \frac{I(t)}{Is} * \exp\ (-Ke * h) \qquad (4\text{-}8)$$

$$\alpha_0 = \frac{I(t)}{Is} \qquad (4\text{-}9)$$

$$I(t) = \begin{cases} Ia * \frac{24}{td-tu} * \frac{\pi}{2} \sin [\pi \frac{t-tu}{td-tu}] & \text{if } tu < t < td \\ 0 \quad \text{if } t < tu \text{ or } t > td \end{cases} \qquad (4\text{-}10)$$

in which

Ke' = light extinction coefficient at zero chlorophyll concentration (1/meter)

Ke = light extinction coefficient corrected for self-shading of plankton (1/meter)

h = depth of water column (meters)

Is = optimum solar radiation rate (langleys/day)

$I(t)$ = solar radiation at time t

Ia = total daily solar radiation (langleys)

tu = time of sunrise, in hours

td = time of sunset, in hours

t = time of day in hours

The nutrient effect, N, is based on the minimum limiting nutrient concept.

$$N = \text{minimum} \begin{cases} \dfrac{N2 + N3}{Kmn + N2 + N3} \\[2ex] \dfrac{P2}{Kmp + P2} \end{cases} \qquad (4\text{-}11)$$

in which

N2 = ammonia nitrogen concentration (mg/l)

N3 = nitrite+nitrate nitrogen concentration (mg/l)

P2 = ortho phosphorus concentration (mg/l)

Kmn = half-saturation concentration for inorganic nitrogen uptake (mg/l

Kmp = half-saturation concentration for ortho phosphorus uptake (mg/l)

The respiration and mortality rates, R and P, are functions of temperature.

$$R = a * Tr \qquad (4\text{-}12)$$

in which

a = respiration rate at 20 C (1/day)

$Tr = \theta r^{T-20}$

$P = b * Tp$

in which

b = mortality rate at 20 C (1/day)

$Tp = \theta p^{T-20}$

2) Organic Nitrogen - The source/sink term for organic nitrogen is expressed

$$SS = V * [- \frac{Kn12 * Tn12}{Kh12 + N1} * N1 + aN * Fron * (R+P) * CH \qquad (4\text{-}13)$$

$$- N1*Kn11/h + BENN1/h] + WN1$$

in which

N1 = concentration of organic nitrogen (mg/l)

Kn12 = hydrolysis rate of organic nitrogen to ammonia at 20 C (mg/l/day)

Tn12 = $\theta n12^{T-20}$

Kh12 = half-saturation concentration for hydrolysis (mg/l)

aN = ratio of organic nitrogen to chlorophyll in phytoplankton (mgN/µgm Chl)

Fron = fraction of phytoplankton nitrogen recycled to organic pool by respiration and death

Kn11 = settling rate of organic nitrogen (m/day)

BENN1 = benthic flux of organic nitrogen (gm/m^2/day)

WN1 = external loading of organic nitrogen (gm/day)

3) Ammonia Nitrogen - The source/sink term for ammonia nitrogen is expressed

$$SS = V * [- \frac{Kn23 * Tn23}{Kh23 + N2} * N2 + \frac{Kn12 * Tn12}{Kh12 + N1} * N1$$

$$+ aN * [(1-Fron) * (R+P) - PR * G] * CH + BENN2/h] + WN2 \quad (4-14)$$

in which

N2 = concentration of ammonia nitrogen (mg/l)

Kn23 = nitrification rate of ammonia to nitrate nitrogen at 20 C (mg/l/day)

Tn23 = $\theta n23^{T-20}$

Kh23 = half-saturation concentration for nitrification (mg/l)

BENN2 = benthic flux of ammonia nitrogen (gm/m^2/day)

PR = preference of phytoplankton for ammonia uptake

$$= \frac{N2 * N3}{(Kmn + N2)*(Kmn + N3)} + \frac{N2 * Kmn}{(N2+N3)*(Kmn + N3)} \quad (4-15)$$

WN2 = external loading of ammonia nitrogen (gm/day)

4) Nitrite+Nitrate Nitrogen - The source/sink term for nitrite-nitrate nitrogen is expressed

$$SS = V * [\frac{Kn23 * Tn23}{Kh23 + N2} * N2 - aN * G * (1-PR) * CH - N3 \quad (4\text{-}16)$$

$$* Kn33/h + BENN3/h]+WN3$$

in which

N3 = concentration of nitrite-nitrate nitrogen (mg/l)
Kn33 = settling rate of nitrite-nitrate nitrogen (m/day)
BENN3 = benthic flux of nitrite-nitrate nitrogen (gm/m^2/day)
WN3 = external loading of nitrite-nitrate nitrogen (gm/day)

5) Organic Phosphorus - The source/sink term for organic phosphorus is expressed

$$SS = V * [- \frac{Kp12 * Tp12}{Khp + P1} * P1 + aP * Frop * (R+P) * CH \quad (4\text{-}17)$$

$$- P1 * Kp11/h + BENP1/h] + WP1$$

in which

P1 = concentration of organic phosphorus (mg/l)
Kp12 = hydrolysis rate of organic to inorganic phosphorus at 20 C (mg/l/day)
Khp = half-saturation constant for hydrolysis (mg/l)
TP12 = $\theta p12^{T-20}$
aP = ratio of organic phosphorus to chlorophyll in phytoplankton (mg P/ug Chl)
Kp11 = settling rate of organic phosphorus (m/day)
BENP1 = benthic flux of organic phosphorus (gm/m^2/day)
WP1 = external loading of organic phosphorus (gm/day)
Frop = fraction of phytoplankton phosphorus recycled to organic pool by respiration and death

6) Ortho Phosphorus - The source/sink term for ortho phosphorus is expressed

$$SS = V * [\frac{Kp12 * Tp12}{Khp + P1} * P1 + aP * [(1-Frop) * (R+P)-G] * CH \qquad (4\text{-}18)$$

$$- P2 * Kp22/h + BENP2/h] + WP2$$

in which

P2 = concentration of ortho phosphorus (mg/l)
Kp22 = settling rate of inorganic phosphorus (m/day)
BENP2 = benthic flux of inorganic phosphorus (gm/m^2/day)
WP2 = external loading of ortho phosphorus (gm/day)

7) Carbonaceous Biochemical Oxygen Demand - The source/sink term for CBOD is expressed

$$SS = V * [- Kc * Tbod * CBOD + aC * aco * P * CH \qquad (4\text{-}19)$$

$$- CBOD * Ksc/h] + WCBOD$$

in which

CBOD = concentration of carbonaceous biochemical oxygen demand (mg/l)
Kc = first-order decay rate of CBOD at 20 C (1/day)
Tbod = θbod^{T-20}
aC = ratio of carbon to chlorophyll in phytoplankton (mg C/ug Chl)
aco = ratio of oxygen demand to organic carbon recycled = 2.67
Ksc = settling rate of CBOD (m/day)
WCBOD = external loading of CBOD (gm/day)

8) Dissolved Oxygen - The source sink/term for dissolved oxygen is expressed

$$SS = V * [- Kc * Tbod * CBOD - ano * \frac{Kn23*Tn23}{Kh23+ N2} * N2 \qquad (4\text{-}20)$$

$$+ aco * aC * PQ * G *CH - aco * aC/RQ * R * CH$$

$$+ Kr * (DOs - DO) - BENDO/h] + WDO$$

in which

DO = dissolved oxygen concentration (mg/1)
ano = ratio of oxygen consumed per unit of ammonia nitrified = 4.33
PQ = photosynthesis quotient (moles O2/mole C)
RQ = respiration quotient (moles CO2/mole O2)
Kr = reaeration rate (1/day)
DOs = saturation concentration of DO (mg/1)
BENDO = sediment oxygen demand ($gm/m^2/day$)
WDO = external loading of dissolved oxygen (gm/day)

The expression utilized to compute the reaeration coefficient, Kr, combines the effects on reaeration of turbulence within the water body (O'Connor and Dobbins: 1958) and wind above the water body (Banks and Herreran, 1977). The expression

$$Kr = \frac{1}{h} * Kro * [\frac{u}{h}]^{1/2} + \frac{1}{h} (0.384 * W^{1/2} \qquad (4\text{-}21)$$

$$- 0.088 * W + 0.0029 * W^2) * Tdo$$

in which

Kr = reaeration rate (1/day)
Kro = proportionality constant
$Tdo = \theta do^{T-20}$
u = mean cross-sectional velocity (m/sec)
W = wind velocity (km/hr)

Saturation dissolved oxygen concentration, DOs, is calculated as a function of water temperature from a polynomial fitted to the tables of Carritt and Green (1967).

$$DO = 14.6244 - 0.367134 * T + 0.004497 * T^2 \qquad (4\text{-}22)$$

CHAPTER V. APPLICATION OF THE HYDRODYNAMIC MODEL

Before the hydrodynamic model can be utilized, it must be supplied with the geometry of the water body to be modelled. Next, model predictions of surface level and current velocity should be compared to field measures of these parameters. Finally, the ability of the model to predict the transport of dissolved substances should be verified through comparison of model predictions and field measures of the concentration of some conservative substance such as dye or salt. The completion of each of these procedures is detailed in this chapter.

A. Geometry

As noted in Chapter IV, the solution to equations 4-1 through 4-3 is accomplished through division of the water body into a series of finite segments which together approximate the continuous system. The hydrodynamic model must be supplied with the geometry of each of these segments including measures of length, width, depth, cross-section, surface area, and volume.

The Aquia Creek is divided into twenty-six segments along the axis (Fig. 5-1). The geometry of these segments is derived from bathymetry measurements taken in 1981 (Fig. 5-2) and from U.S.G.S. topographic maps of the Stafford and Widewater quadrangles.

Specification of the segment geometry is complicated by the irregular shape of the creek and by the marshy areas. Cross-sectional area, surface area, and volume cannot be considered constant, but are instead computed within the model as time-variable functions of surface level. Segment geometries at the mean-tide level are presented in Table

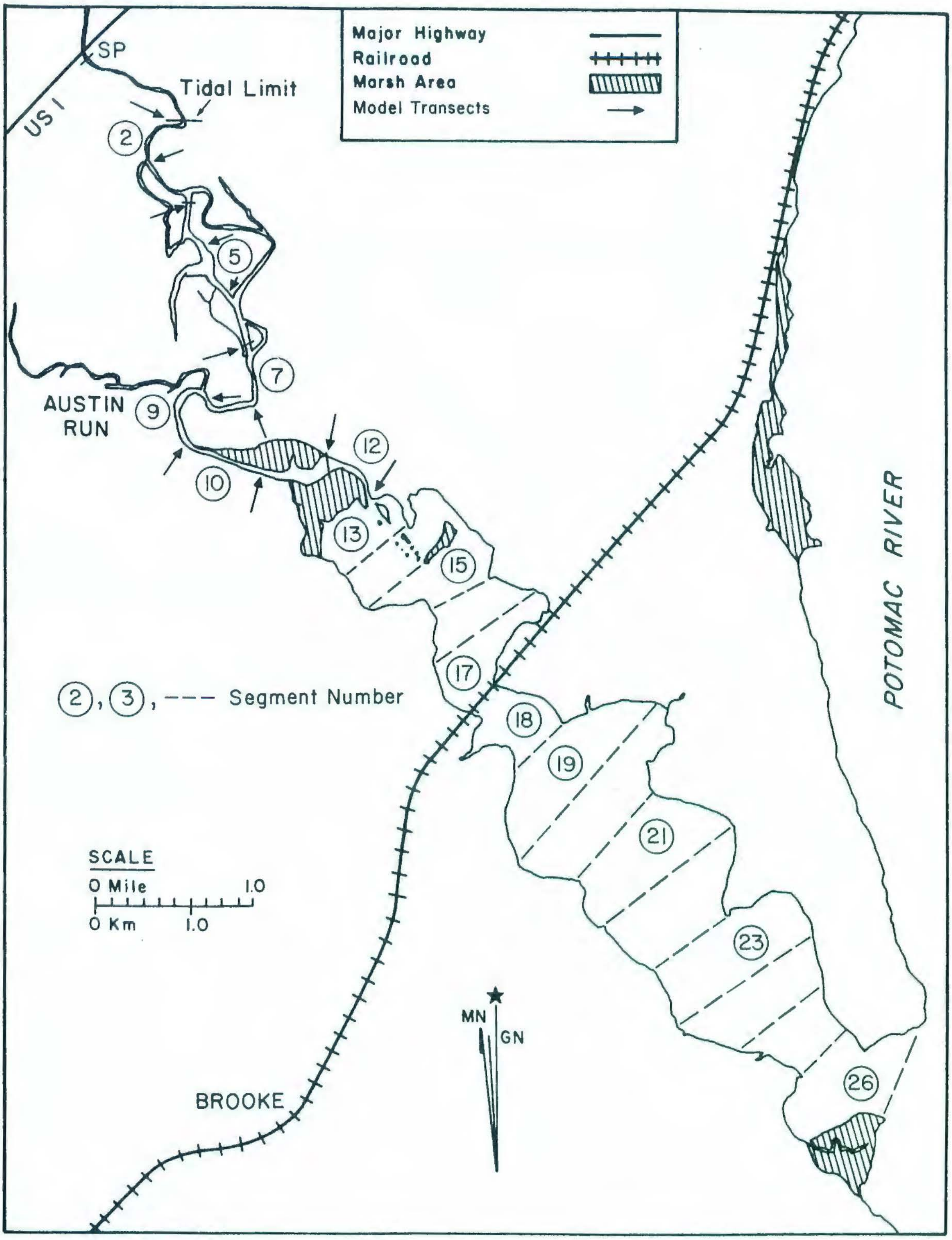


Figure 5-1. Model segmentation of Aquia Creek.

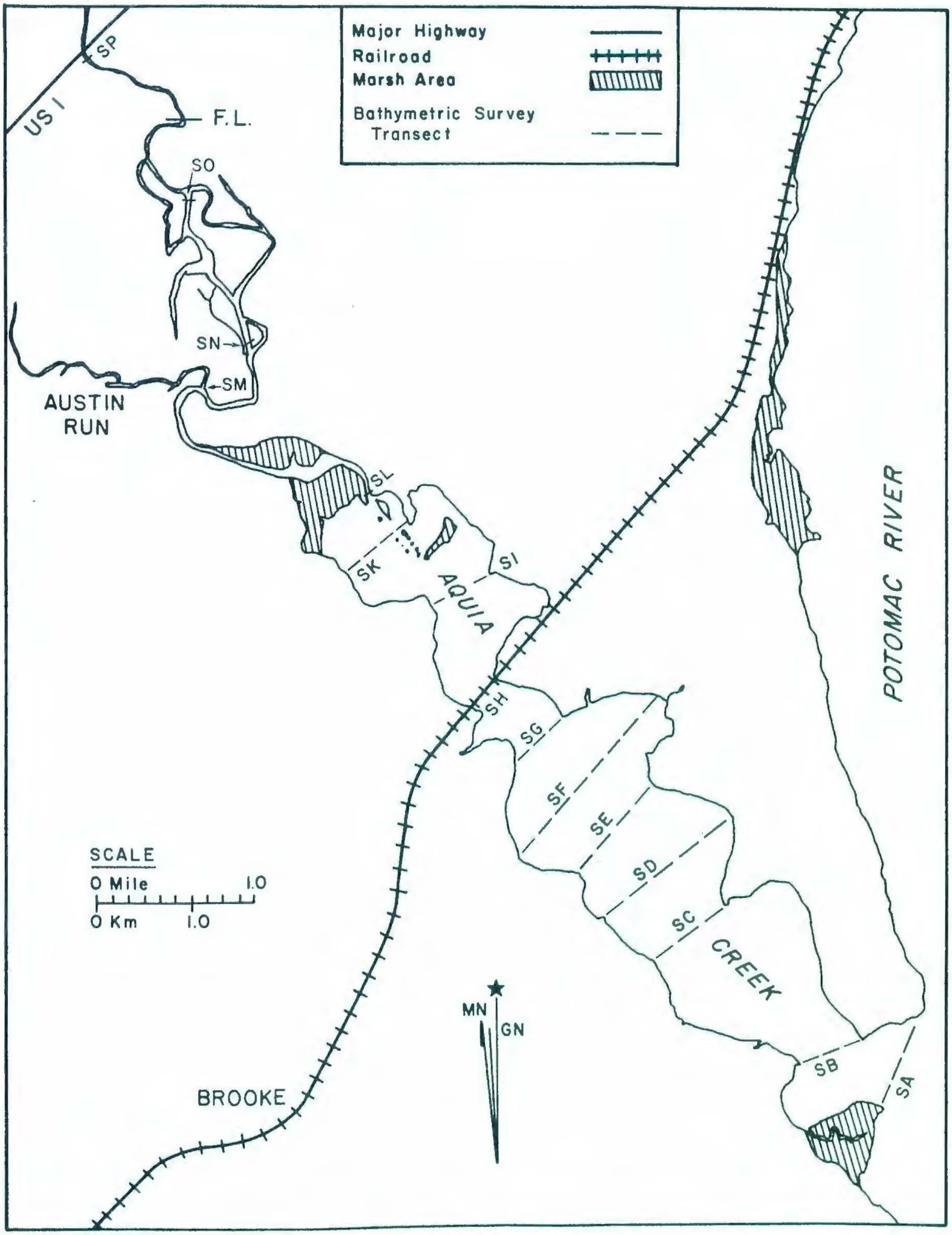


Figure 5-2. Location of bathymetry measurements.

5-1. Note that for some of these segments, the surface area or volume are much larger than the product of the segment length and transect width or area. The additional area and volume are due to the irregular segment geometry and the intratidal volume of the marshes previously mentioned. Measures of the extent of these areas were obtained by planimetry of a topographic map.

B. Calibration of Tide and Current

The ability of the model to predict surface level and current velocity within the creek was tested by completing a series of model runs employing observed tides at the mouth and freshwater flows upstream of tidal limit as boundary conditions. The model runs were started several days prior to the period in which the current meters and tide staffs were installed, in order to eliminate transient effects. The predicted tides and currents within the creek were then compared with measurements collected at these locations. The value of the bottom friction coefficient expressed as Manning's n, in Eq. 4-2, was adjusted until the model results agreed satisfactorily with the prototype data.

Predictions and observations of tidal height and current are compared in Figures 5-3 and 5-4. No tide staff was installed at stations 2 and 3. The current meter at station 2 malfunctioned and yielded no data for comparison with model prediction.

Predicted and observed tides at the mouth are in perfect agreement, as they should be, since the tide at the mouth is input to the model as a boundary condition. Attention is directed to the comparisons of predictions and observations at stations 4, 5, 6 and 7 (Fig. 5-4). The near-perfect agreement at these stations demonstrates

Table 5-1. Segment Geometry at Mean Tide

Transect or Segment	Distance from Mouth (km)	Surface Width (m)	Depth (m)	Cross Sectional Area (m^2)	Surface Area ($10^3 m^2$)	Volume ($10^3 m^3$)
2	13.50	16.0	0.36	5.8	7.90	3.24
3	12.86	20.0	0.46	9.2	37.7	13.3
4	12.20	25.7	0.56	14.3	26.1	13.1
5	11.73	43.7	0.87	38.0	53.5	34.3
6	11.26	52.9	1.19	63.0	50.0	33.4
7	10.79	56.3	1.51	84.9	21.8	27.9
8	10.19	49.0	1.55	76.0	17.3	27.4
9	9.59	42.0	1.60	67.2	18.6	29.7
10	8.99	41.9	1.67	70.0	22.3	36.4
11	8.39	43.8	1.67	73.0	54.5	92.7
12	7.79	129.5	1.78	230	43.4	82.8
13	7.19	65.5	2.01	135	238	219
14	6.83	733	0.78	571	442	293
15	6.37	647	0.85	550	323	220
16	5.99	570	0.95	539	346	356
17	5.55	1180	1.10	1300	342	455
18	5.12	307	1.57	483	330	429
19	4.47	621	1.24	772	784	902
20	3.92	1903	1.05	1997	758	948
21	3.41	1030	1.45	1492	762	1127
22	2.86	1458	1.51	2205	609	902
23	2.33	823	1.44	1184	602	867
24	1.82	1530	1.44	2200	650	923
25	1.31	1035	1.40	1450	353	639
26	0.08	640	2.22	1424	673	914
27	0.00	995	1.43	1427		

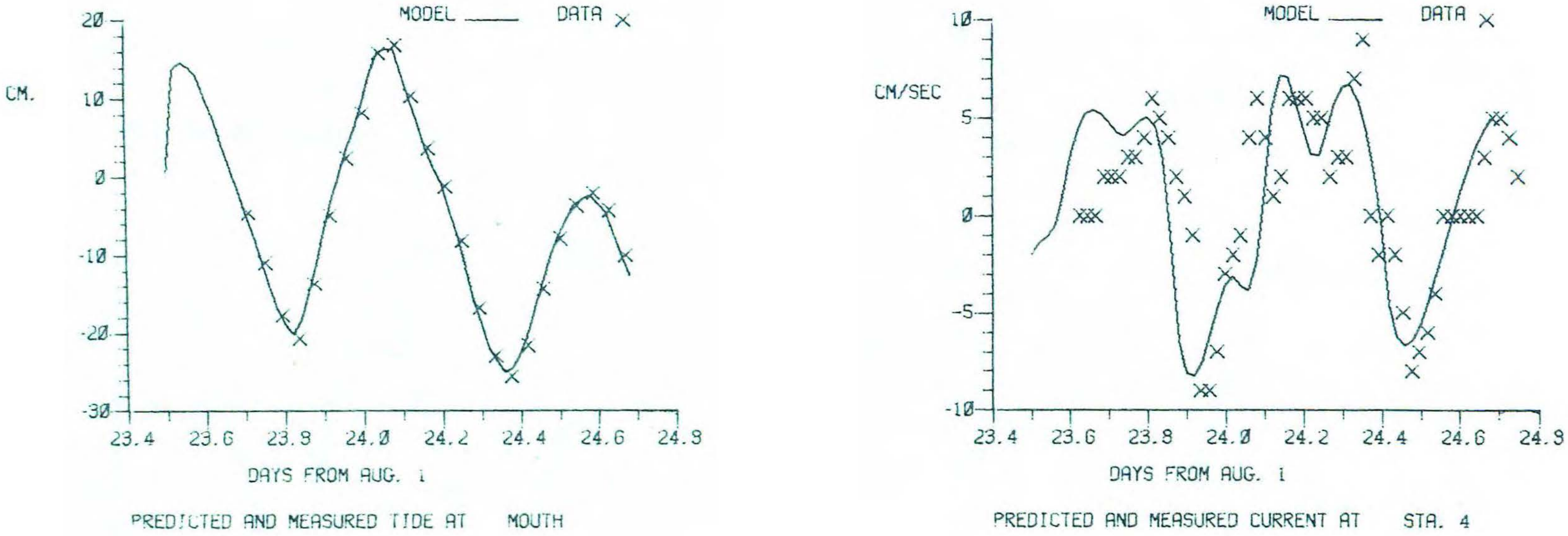
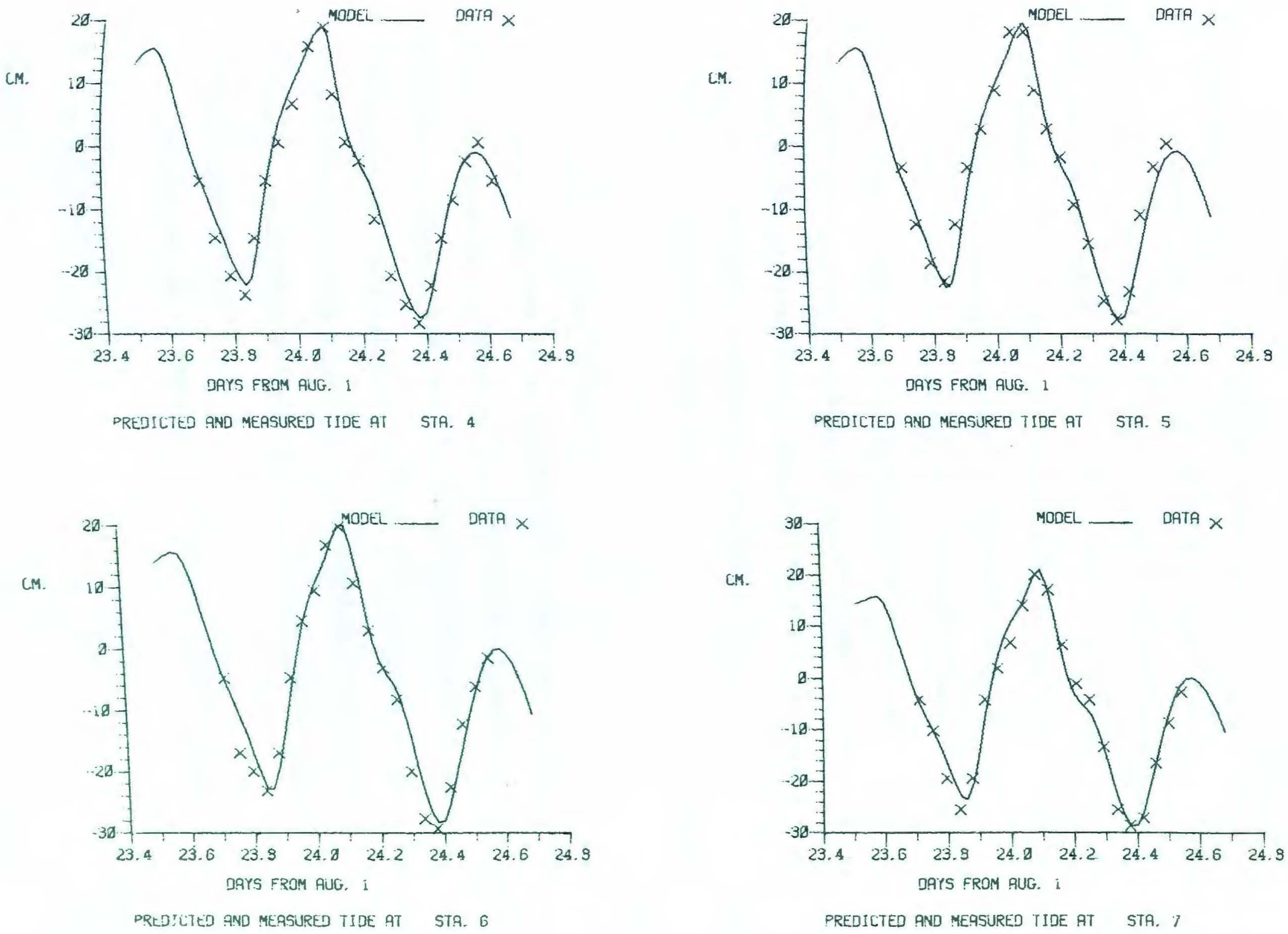


Figure 5-3. Boundary condition at mouth and verification of current.



PREDICTED AND MEASURED TIDE AT STA. 4

PREDICTED AND MEASURED TIDE AT STA. 5

PREDICTED AND MEASURED TIDE AT STA. 6

PREDICTED AND MEASURED TIDE AT STA. 7

Figure 5-4. Calibration of tide.

that the model is capable of predicting accurately the surface level throughout the creek.

Comparisons of the predicted and observed currents are less ideal than the tides (Fig. 5-3). Discrepancies exist here largely due to the means of collecting velocity data and to conceptual differences between the model and the data. The current meters employed measure velocity instantaneously at a single point in the spatial domain. The model, however, provides predictions averaged temporally over a model time step, $\nabla t = 29$ minutes, and spatially along the lateral and vertical axes. Thus the model provides relatively smooth, deterministic currents for comparison with data affected by spatial non-uniformities, random turbulence, wind gusts, and boat traffic. Allowing for these elements, the model predictions of current are good and more than sufficient for their intended use.

C. Calibration of Mass Transport

In the last test of the hydrodynamic model, the ability to predict the transport of a conservative substance is examined. A dye study, conducted in August, 1981 and described in Chapter III is available for this purpose. Calibration is achieved via evaluation of the dispersion term of Eq. 4-3 and by adjustment of a weighting coefficient, α, which determines the dissolved substance concentration in the flow between adjacent segments.

Dispersion, E, is computed by Harleman's (1971) formula

$$E = E_o * n * u * R^{5/6} + E_o' \qquad (5\text{-}1)$$

in which

E = dispersion coefficient (m^2/sec)

E_o = proportionality constant

E_o' = minimum dispersion coefficient at slack tide (m^2/sec)

n = Manning's friction coefficient

u = velocity (m/sec)

R = hydraulic radius (m)

The values of $E_o = 63.2$ and $E_o' = 1$ were found suitable for model use.

The weighting coefficient α is utilized in the equation

$$C_i^* = \alpha_i * C_{i-1} + (1 - \alpha_i) * C_i \qquad (5\text{-}2)$$

in which

α_i = weighting coefficient for transect i ($0.5 \leq \alpha \leq 1.0$)

C_i^* = concentration of dissolved substance flowing from segment i-1 to segment i

C_{i-1} = concentration of dissolved substance in segment i-1

C_i = concentration of dissolved substance in segment i

A value of $\alpha = 1.0$ corresponds to a backwards finite-difference scheme. A value of $\alpha = 0.5$ corresponds to a central differencing scheme. This formulation assumes that flow is coming from the (i-1)th segment into the ith segment. When tidal flow reverses, the roles of α and $1-\alpha$ are reversed. Details of the employment of the weighting factor in the finite difference scheme may be found in Williams and Kuo (1983). A value of $\alpha = 0.75$ was used for all transects except the most upstream one where $\alpha = 1.0$ was used.

In conventional dye studies of large water bodies, sufficient time is allowed between the dye release and the initiation of sampling for the dye to mix uniformly laterally and vertically and to form a smooth distribution longitudinally. In small embayments such as the Aquia Creek, however, the luxury of an extended initial mixing period is not available, the residence time of the embayment is too short and the risk of a ruinous meteorological event is great. If a lengthy mixing period were allowed, much of the dye would be lost from the system and a wind event or rainstorm might render the data set useless.

Without a lengthy mixing period, the dye distribution in the creek is patchy and non-uniform which poses problems in the interpretation of the samples and in specification of initial conditions for the model. Dye concentration in the initial samples fluctuates widely due as much to the random distribution of dye as to any deterministic transport process. Because the initial dye distribution cannot be discerned, model initial conditions based on the distribution cannot be specified.

The problem of posing initial conditions is solved by specifying the initial mass of dye in the system rather than the initial spatial distribution of dye. The dye mass, 9.06 kg, is assumed to be uniformly distributed in the model segments comprising the portion of the creek into which the dye was observed to disperse over the period (half tidal cycle) of release, segments 13, 14 and 15. The resulting initial concentration in these segments is 9.7 ppb.

Due to the patchy initial distribution of the dye, agreement cannot be expected between predictions and observations of instantaneous dye concentration. Instead, dye distributions at subsequent slack tides after release are compared with tidal-averages and the range of dye concentrations predicted by the model for the appropriate cycles.

To summarize, dye calibration is conducted in the following manner:

1) Initial dye concentration in model segments 13, 14 and 15 is specified based on the mass of dye released to the system.

2) Observed field data at slack tides are compared with the average and range of model predictions for 1, 2, 4, 6 and 8 tidal cycles after the dye release.

Results of the dye calibration are shown in Figure 5-5. Good agreement is noted between the predicted and observed dye concentrations although some data points lie outside the model range. This may be attributed as much to the non-uniform distribution of dye and the limited number of data points as to any shortcomings in the model, however.

It should be noted that comparison of model predictions to data which is both temporally and spatially variable is the most rigorous test to which a model can be subjected. Agreement is much more difficult to obtain than under conditions in which spatially-variable but temporally-constant data is employed. Thus, the result of this calibration of mass transport is considered to be most satisfactory.

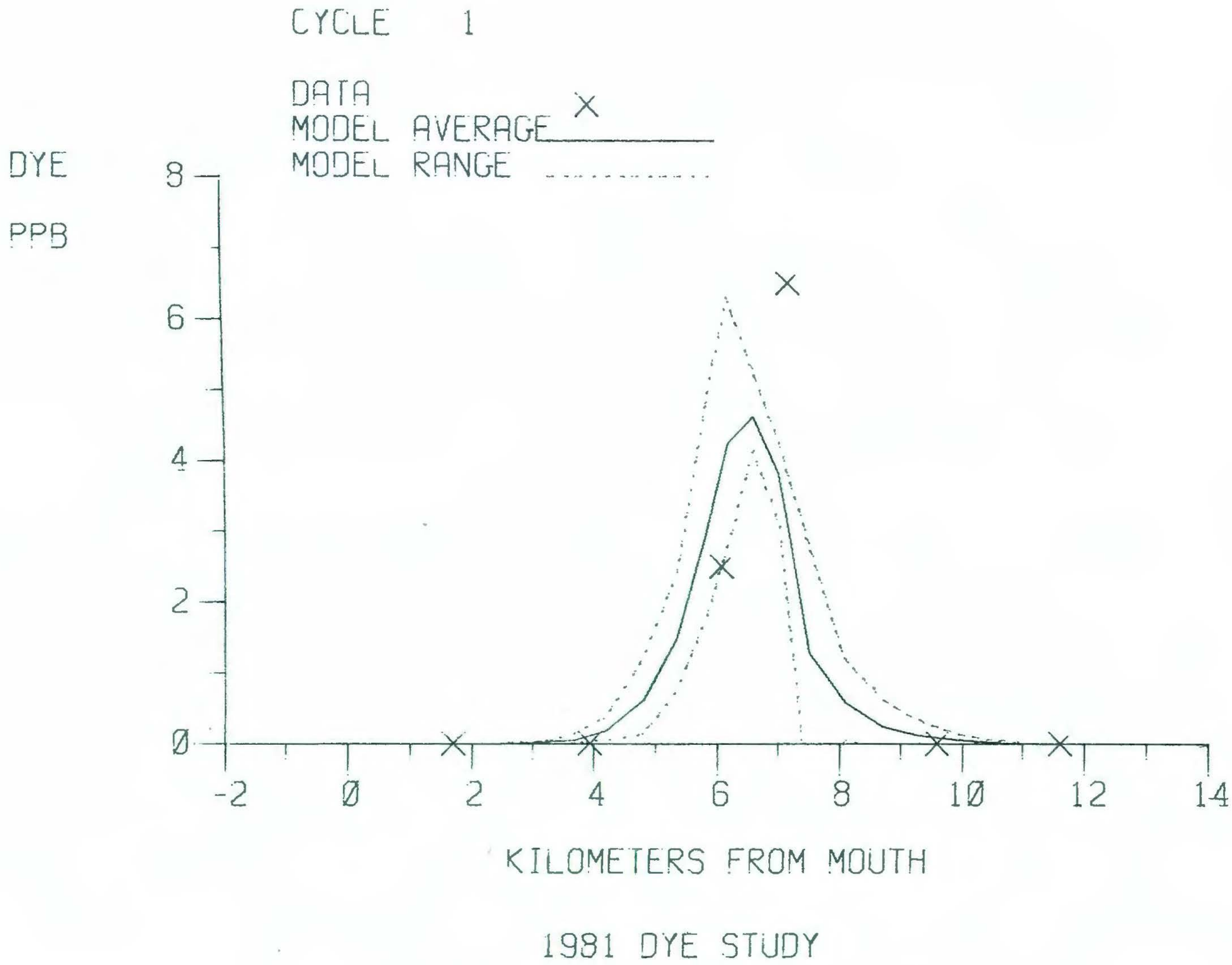


Figure 5-5. Calibration of dye dispersion.

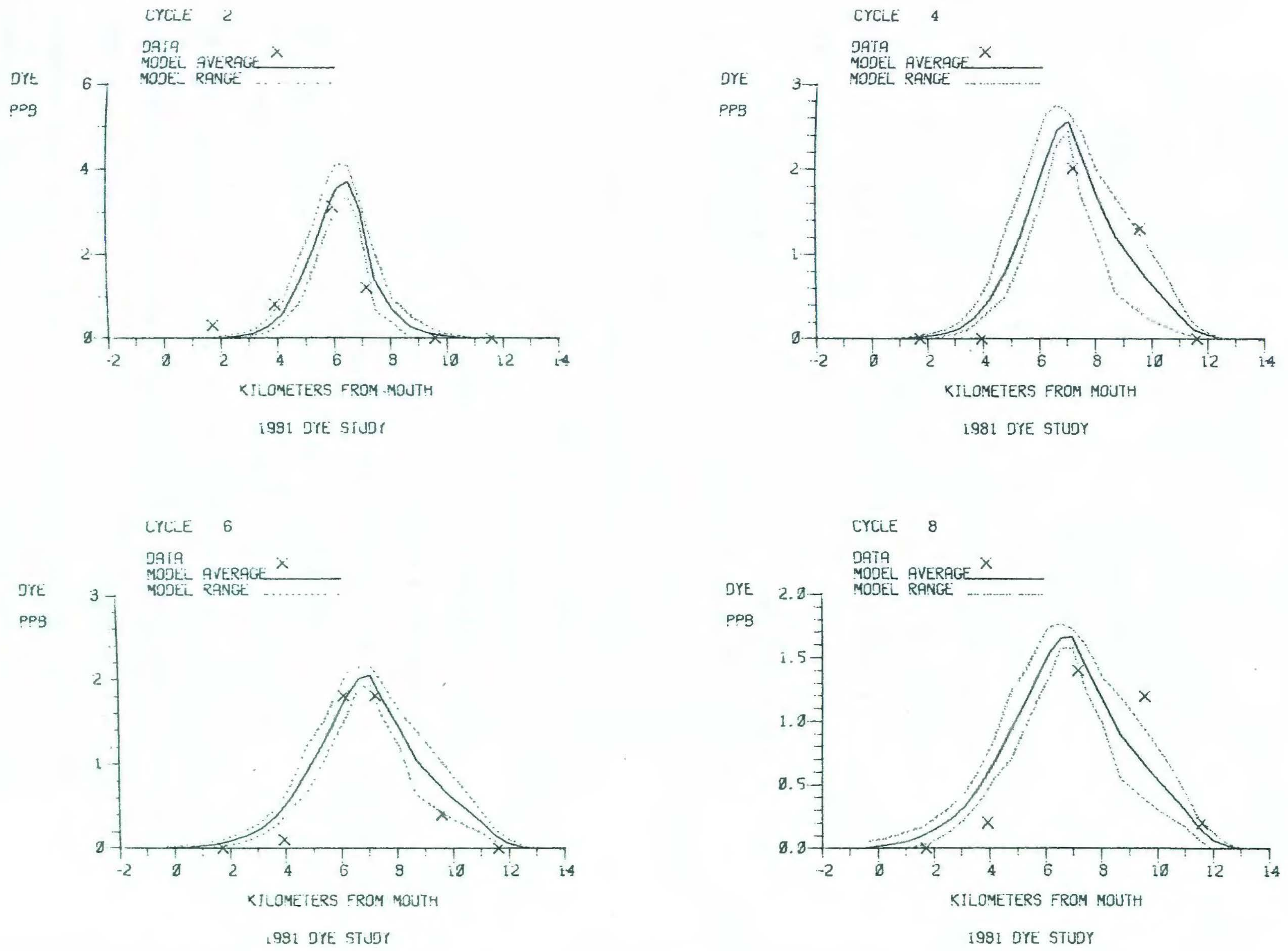


Figure 5-5. (Cont'd).

CHAPTER VI. APPLICATION OF THE WATER-QUALITY MODEL

A. Rationale for Calibration and Verification

Application of the water-quality model is similar to that of the hydrodynamic model. The model must be supplied with appropriate input data and boundary conditions and then calibrated to reproduce the observed prototype behaviors through the adjustment of various coefficients, most notably the biogeochemical rate constants described in Chapter IV. Following the calibration, the selection of coefficients should be verified through comparison of model predictions with additional independent field data.

Calibrating and verifying the water-quality model is much more difficult than the hydrodynamic model due to the number of predicted parameters to be calibrated - organic, ammonia, and nitrite-nitrate nitrogen, total and ortho phosphorus, chlorophyll, CBOD, and D.O. - and to the large number of coefficients which may be adjusted in attaining the calibration. In some instances it may be possible for alternate sets of calibration parameters to provide roughly equivalent calibrations and verifications. To avoid this situation, it is desirable to minimize the number of coefficients which are evaluated through comparison of model results to field data.

There are a variety of sources for the data and coefficients used in this model. Among these are measurements, literature values, and calibration. Measurements include inputs such as water temperature and STP wasteloading. Literature values are coefficients which have been evaluated in published studies of similar systems. For this modelling effort, the primary literature sources are the 'Calibration and

Verification of a Mathematical Model of the Eutrophication of the Potomac Estuary' (Thomann and Fitzpatrick, 1982), hereinafter referred to as the 'COG Report', and 'Water Quality in a Virginia Potomac Embayment: Hunting Creek - Cameron Run' (Cerco and Kuo, 1983), hereinafter referred to as the 'HCK Report'. Calibration parameters are those which are obtained through fitting of the model to observations.

The number of calibration parameters employed in the calibration and verification procedures is minimized through adherence to the following principles in evaluating model parameters:

1) Utilize measurements of system inputs and biogeochemical constants and coefficients whenever these are available.
2) Utilize values from the literature when measurements are not available.
3) Utilize calibration values only when no other sources are available or when other sources are proven unsuitable.

B. Consistency of the Calibration and Verifications

To be of optimal use, a water quality model ought to employ consistent values of biogeochemical constants and transformation rates. That is, these values should be transferable when the model is used to provide predictions for comparison with independent sets of observations. Coefficients which are not constant should be calculable based on ambient conditions of temperature, light, wind, etc. If the model is not consistent, then its predictive value is reduced since any predictions will depend upon the selection of coefficients from the range of values previously employed.

The ideal of consistency imposes a dilemma upon the modeller. He must provide a consistent model of an inconsistent world. In the prototype, biogeochemical constants and rates need not be consistent from survey to survey, season to season, or year to year, yet in the model this must be so.

In the calibration and verification to follow, the principle of consistency is adhered to wherever possible. The trade-off is that predictions and observations do not always agree as closely as they might if the model were adjusted to each survey individually. Discrepancies between predictions and observations must therefore be regarded as illustrative of the variability of natural processes rather than indicative solely of shortcomings in the model.

C. The Calibration and Verification Data Bases

1) Instream water quality data

The water quality data described in Chapter III may be grouped into two independent data sets. Model calibration is achieved using the data from intensive survey, with verification conducted employing the data from slack water surveys.

2) Point source loadings

The Aquia STP is the only discharge of point source into the creek. Two sources of discharge data are available. One is the monitoring by Virginia State Water Control Board during the survey period of this project. The other is the Discharge Monitoring Report (DMR) which the STP operator submitted to SWCB monthly.

The STP effluent was sampled by SWCB once during each slackwater survey, and four times during the intensive survey. The samples were analyzed for concentrations of water quality parameters. The results are included in Appendices as station 9, and summarized in Table 6-1(a). The data show that the phosphorus concentrations are rather constant at

Table 6-1. Aquia STP Effluent Concentrations
(all units are in mg/l except noted)

(a) Monitored by SWCB

Date	Org-N	NH_4-N	NO_3-N	Org-P	Ortho-P	$CBOD_u$	DO
5/26	6.5	2.5	2.25	0.40	5.50	19.5	10.6
6/11	4.0	12.5	0.33	0.0	4.80	11.1	7.3
6/23	1.30	1.00	1.12	0.20	4.20	3.91	6.9
7/7	1.40	4.00	1.02	0.10	5.00	8.81	7.2
7/23	0.80	0.60	0.71	0.10	5.00	17.0	7.0
8/5	0.80	0.50	2.21	0.20	4.00	3.70	6.6
8/24-25	3.61	9.40	0.22	0.20	5.00	8.10	6.3
9/21	4.90	9.50	0.21	0.10	5.50	7.11	7.5

(b) Discharge Monitoring Report, Monthly Average

Month	TKN	NO_3-N	Total P	BOD_5	DO	Flow (mgd)
May	14.0(1)	5.01	3.39	4.37	7.4	1.19
June	13.0(1)	1.56	3.97	4.5	6.6	0.90(2)
July	7.44	1.68	5.12	5.2	6.7	(3)
August	9.60(1)	2.00	5.19	6.7	7.1	(3)
Sept.	16.0	1.89	5.44	8.2	7.3	0.55(2)

(1) DMR contained errors in calculation.

(2) Average values of the dates in the month when STP flow meter was operating.

(3) STP flow meter was not functioning.

all times. The nitrogen and CBOD concentrations are quite variable, particularly the ammonia nitrogen for which more than twenty fold variation was observed.

The Discharge Monitoring Report includes daily effluent concentrations of BOD_5, TKN, nitrite nitrogen, total phosphorus and DO. The report also includes flow rate, however, it was reported that the STP flow meter was not functioning from mid-June to mid-September of 1981. The monthly average values of the report are summarized in Table 6-1(b).

The two data sets were merged to define point source input data for the model. Since no flow rate data were available for the period of model simulation, it was impossible to accurately define daily point source loadings. Instead the monthly average loadings were determined. Monthly average flow rates were obtained by linear interpolation of data for early June and late September. Monthly average loadings of TKN, NO_2 plus NO_3 - N, total P and $CBOD_5$ were determined by multiplying monthly average concentrations of DMR with flow rates. The TKN and total P loadings were then partitioned between organic and ammonia nitrogen, and between organic and ortho phosphorus respectively, according to the ratio derived from SWCB monitoring data of the month. $CBOD_5$ loadings were converted to $CBOD_u$ loadings, also according to the ratio derived from SWCB monitoring data. The conversion factors are presented in Table 6-2(a) and the monthly loadings are listed in Table 6-2(b).

Table 6-2(a). Conversion Factors Used to Estimate Point Source Loadings.

	NH_4-N/Org. N (1)	Ortho. P/Org. P (1)	$CBOD_u/BOD_5$ (1)	Flow (mgd)
June	1.95	21	2.93	0.90(2)
July	1.81	50	4.62	0.78(3)
Aug	1.61	22	4.58	0.66(3)

(1) Estimated from SWCB monitoring data (Table 6-1(a), and average over for each month.

(2) Average values of the dates in the month when STP flow meter was operating.

(3) Linear interpolation between values of June and September.

Table 6-2(b). Point Source Loadings Used in Model Simulation (all units are in kg/day except noted).

	Flow m^3/s	Org. N	NH_4-N	NO_3-N	Org. P	Ortho. P	$CBOD_u$	DO (mg/1)
June	0.04	15.0	29.3	5.31	0.61	12.9	44.9	6.7
July	0.035	7.8	14.1	4.96	0.29	14.8	70.9	6.7
Aug.	0.03	9.2	14.8	5.0	0.57	12.4	76.7	7.1

3) Nonpoint source loadings

Daily nonpoint source loadings were supplied by the Northern Virginia Planning District Commission (NVPDC). Appendix C shows the comparison between these loadings and observed values. The observed values were derived from data of stations 8 and 10. The only major discrepancies are in dissolved oxygen, where the NVPDC D.O. concentrations are apparently at saturation levels, and in nitrite-nitrate nitrogen, where the NVPDC loadings are always much higher than measured values.

Table 6-3 compares the measured and predicted concentrations of pollutants in the nonpoint source runoff. The predicted values were calculated from the flow rates and loadings provided by NVPDC. The measured values are the weighted averages of concentrations at stations 8 and 10, with measured flow rates as weighting factors. Except for nitrite-nitrate nitrogen the differences between the measured and predicted pollutant concentrations are within a factor of 2, and thus, the NVPDC predictions are deemed to be satisfactory. A simple analysis was performed on the D.O. and nitrite-nitrate nitrogen data. It was determined that the average ratios of measured values to predicted values were about 0.8 and 0.25 for D.O. and nitrite-nitrate nitrogen respectively. Therefore, the predicted values of the daily nonpoint source of D.O. and nitrite-nitrate nitrogen were adjusted accordingly for model input.

4) Benthic fluxes

The field measurements of benthic D.O. and nutrient fluxes are described in Chapter III. The field data and model inputs are presented in Table 6-4. The nitrite-nitrate nitrogen and ortho phosphorus fluxes

TABLE 6-3. Concentrations of Nonpoint Runoff as Predicted by NVPDC and Field Measurements

		Flow	Org. N	NH_4-N	NO_2+NO_3N	Org. P	Ortho P	CBOD	DO	Chl.
5/26	NVPDC	1.66	0.24	0.036	0.41	0.034	0.012	1.67	9.3	4.5
	Field	-	0.29	<0.1	0.09	<0.08	0.02	2.3	7.4	2.5
6/11	NVPDC	1.07	0.22	0.036	0.43	0.034	0.012	1.51	8.8	2.5
	Field	0.25	0.26	0.17	0.11	<0.08	0.013	1.82	7.4	1.3
6/23	NVPDC	1.39	0.18	0.025	0.42	0.026	0.012	1.08	8.4	2.1
	Field	1.65	0.39	<0.10	0.09	<0.06	0.04	2.15	6.3	-
7/7	NVPDC	0.97	0.18	0.031	0.43	0.029	0.012	1.23	8.3	1.8
	Field	0.81	0.28	<0.10	0.06	<0.09	0.01	2.06	7.5	1.8
7/23	NVPDC	0.38	0.17	0.040	0.43	0.031	0.012	1.25	8.5	1.1
	Field	-	0.20	<0.10	0.13	<0.09	0.01	2.57	8.8	2.4
8/5	NVPDC	0.72	0.26	0.031	0.44	0.034	0.016	1.45	8.1	3.5
	Field	0.48	0.23	<0.10	0.06	<0.09	0.013	1.81	7.2	0.5
8/24	NVPDC	0.33	0.20	0.042	0.42	0.032	0.014	1.51	8.7	2.4
	Field	-	0.19	0.14	0.14	<0.08	0.01	2.1	9.3	0.5
8/25	NVPDC	0.32	0.20	0.04	0.42	0.033	0.015	1.45	8.7	2.3
	Field	-	0.21	0.15	0.13	<0.08	0.01	1.8	8.0	1.3
9/23	NVPDC	0.79	0.22	0.035	0.38	0.031	0.013	1.54	9.2	3.9
	Field	0.25	0.20	<0.10	0.06	<0.09	0.01	2.57	10.3	-

Note: Flow in m^3/s, chlorophyll in ug/l, all others in mg/l.

TABLE 6-4. Benthic Fluxes

(a) Field Data

Station	DO* ($gm/m^2/day$)	Ammonia-N ($gm/m^2/day$)	NO_2 + NO_3-N ($gm/m^2/day$)	Ortho P ($gm/m^2/day$)
2	2.2, 2.3	0.08	0.01	0.01
4	1.7, 2.3	0.06	0	0
5	1.3			
6	1.1	0.03	0	0

(b) Model Inputs**

Segment Number	2	3	4	5	6	7	8	9	10	11	12	13	14
DO*	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.3	1.4
NH_3-N	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03

Segment Number	15	16	17	18	19	20	21	22	23	24	25	26
DO*	1.5	1.6	1.7	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0
NH_3-N	0.03	0.06	0.06	0.06	0.06	0.06	0.08	0.08	0.08	0.08	0.08	0.08

*The DO fluxes are expressed in terms of benthic DO demand. Positive values mean DO lost from water column.

**A uniform flux of -0.02 $gm/m^2/day$ of nitrite-nitrate nitrogen and zero flux of ortho phosphorus were used as model input.

were measured to be zero at two stations and near zero at the other. No benthic fluxes were input to the model for ortho phosphorus. The fluxes of organic nitrogen and organic phosphorus were also assumed to be zero.

Initial calibration runs with zero benthic flux of nitrite-nitrate nitrogen provided predictions of nitrite-nitrate nitrogen in excess of the observed concentrations throughout the creek. In order for the model predictions to match field measurement from the intensive survey, a uniform benthic flux of -0.02 gm/m^2/day was introduced as a form of denitrification process. Due to the variability of natural systems and to the difficulty of conducting benthic flux measurement, the single measurement of nitrogen flux at given station can be considered as indication of order of magnitude only.

Denitrification is a bacteria process in which nitrate is used by some bacteria and fungi for respiration in place of oxygen. The nitrate is reduced to nitrogen gas through the process. It is generally accepted that denitrification requires essentially anoxic condition (Brezonik, 1977). The sediment-water interface is an ideal location for denitrification. Sediments, particularly those in the vicinity of sewage outfall, are usually permanently anoxic within a few mm of the surface and furthermore are generally rich in organic matter on which a nitrifying flora can grow. Since nitrate cannot be found under anoxic conditions, it must be supplied from elsewhere. Diffusion of nitrate downward from the overlying water could be a major source, thus resulting in a benthic flux of nitrate. Edwards and Rolley (1965) found denitrification rates varying from 0.1 to 1.5 gram/m^2/day in the sediment of an English River. Denitrification rates varying from .065 to 1.1 gram/m^2/day with an average nitrate removal rate of 0.9

gram/m^2/day were estimated by Van Kessel (1977) for an 800 meter stretch of a canal receiving sewage effluent. His laboratory experiments with undisturbed water-sediment profiles from the canal showed that the disappearance of nitrate was caused mainly by denitrification in the sediment. In modelling other Potomac embayments, such as Hunting Creek (Cerco and Kuo, 1981), Little Hunting Creek (Williams and Kuo, 1984) and Gunston Cove (Cerco and Kuo, in press), it was found that inclusion of denitrification process in the model was necessary.

5) Boundary conditions

The downstream boundary conditions were specified with the field data observed at station 1. The concentrations at the boundary were updated at times halfway between the slackwater surveys, when the data are available.

6) Water temperature

Model input of water temperature was based on slackwater and intensive survey data. Temperature was updated about every two weeks, at times halfway between slackwater surveys.

7) Solar radiation and light extinction coefficient

Solar radiation was calculated in the model with equation 4-10. The times of sunrise and sunset, tu and td, were updated about every two weeks when boundary conditions and water temperature were updated. Daily solar radiation, Ia, was input everyday of model simulation. The data were obtained from the measurement at Rockville, Maryland.

Light extinction coefficients were derived from Secchi-depth measurements and are shown in Figure 6-1. A good deal of scatter is apparent in the data. The values used for model calibration are indicated in the figure. The values used for model verification were

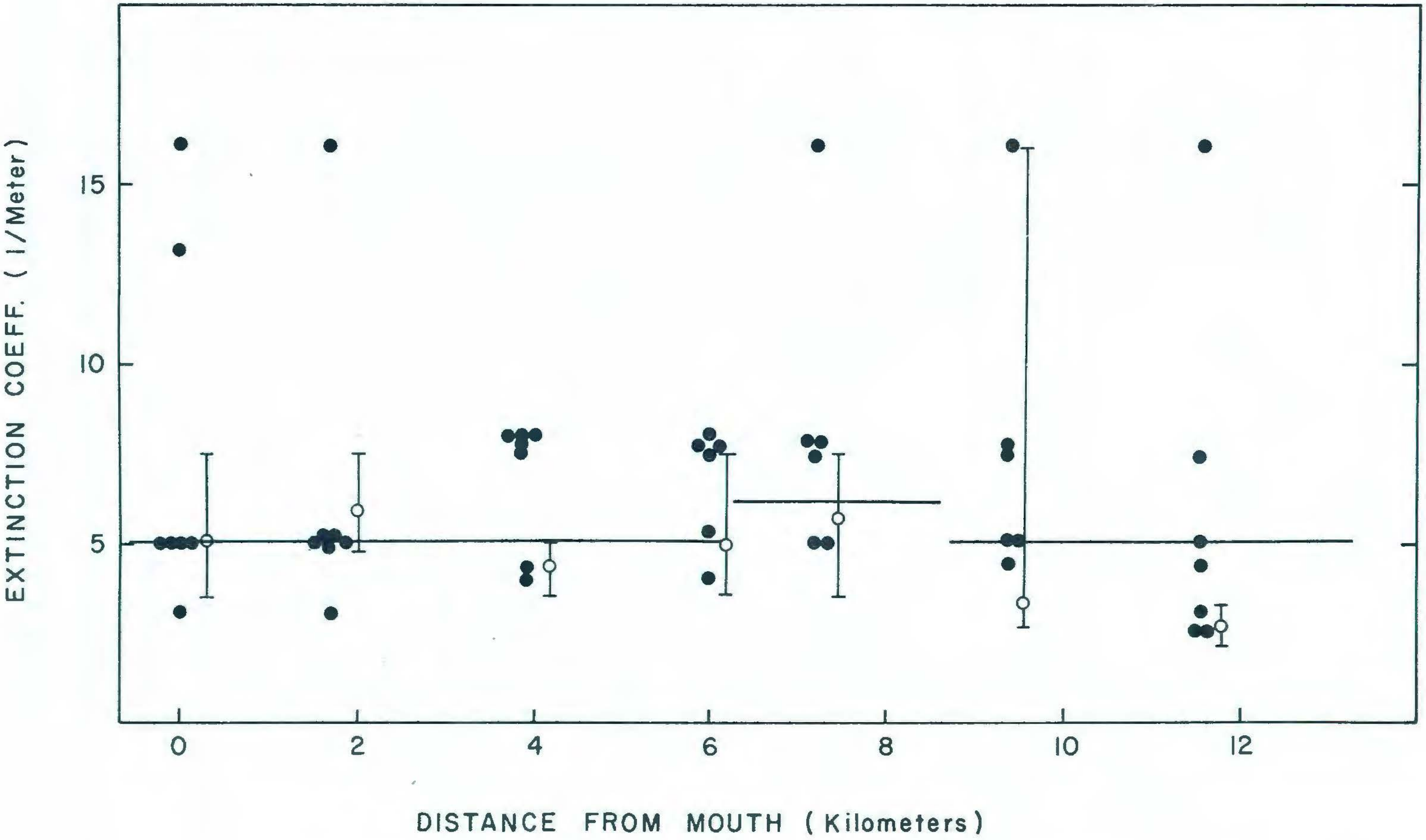


Figure 6-1. Light extinction coefficient. (• slackwater survey, ⌶ mean and range of intensive survey, —— values used for model calibration)

updated every two weeks with those derived from secchi-depth measured at slackwater surveys. The extinction coefficients had an average value of 5.0/meter, with lower values at upstream reaches and higher values at the middle reaches of the creek.

8) Wind speed

The wind induced reaeration was included in equation 4-21 to calculate reaeration coefficient. Daily wind speed was input to the model with data measured at Washington National Airport. However, the wind effect was incorporated for the broader part of the creek only, i.e., downstream of segment 15.

D. Calibration of Intensive Survey

The calibration is conducted by using the observations collected in the August 5 slackwater survey as initial conditions in a model simulation of the period from August 5 through August 25. Model predictions for the period 1300 hrs August 24 - 1500 hrs August 25 are then compared with the intensive-survey data collected in the same time interval. In successive model runs, calibration parameters are adjusted until agreement is achieved between the model predictions and the data.

To conduct the simulation, the model requires evaluation of a number of constants and coefficients. The manner in which these are obtained and the values employed are as significant as the achievement of calibration itself. Therefore, all model coefficients and their origins are presented before the calibration results.

1) Phytoplankton-Related Coefficients - The phytoplankton-related coefficients employed in the calibration are presented in Table 6-5. As

TABLE 6-5. Phytoplankton-Related Coefficients

Coefficient	Equation	Value	Source
aC	4-19	0.050 mg/µg	see text
aN	4-13,14,16	0.007 mg/µg	'
aP	4-17,18	0.001 mg/µg	'
PQ	4-20	1.4 mole/mole	Calibration
RQ	4-20	1.0 mole/mole	'
Kmn	4-11,15	0.025 mg/l	COG Report
Kmp	4-11	0.001 mg/l	'
Kgr	4-5	2.0/day	'
a	4-12	0.125/day	'
Is	4-8,9	250 langleys/day	HCK Report
Ksch	4-4	0.1 m/day	COG Report
P	4-4,13,18	0.1/day	Calibration
θ gr	4-5	1.068	COG Report
θ r	4-12	1.045	Calibration
θ p		1.045	'

TABLE 6-6. Nitrogen-Related Coefficients

Coefficient	Equation	Value	Source
Kn12	4-13,14	0.06 mg/l/day	Calibration
Kh12	4-13,14	1.0 mg/l	HCK Report
Kn11	4-13	0.1 m/day	calibration
BENN1	4-13	0.0 gm/m^2/day	'
Kn23	4-14,16,20	0.30 mg/l/day	'
Kh23	4-14,16,20	1.0 mg/l	HCK Report
BENN2	4-14	0.03-0.08 gm/m^2/day	Measured
BENN3	4-16	-0.02gm/m^2/day	Measured,Calibration
θn12		1.04	Calibration
θn23		1.04	'
Fron	4-13,14	0.75	'

noted in the table the evaluations of several of these parameters merit additional discussion.

Initial attempts were made to derive the carbon-to-chlorophyll, nitrogen-to-chlorophyll, and phosphorus-to-chlorophyll ratios through analysis of the field data. These may be evaluated through equations similar to 3-1 and 3-2:

$$aC = TOC/CH \qquad (6\text{-}1)$$

$$aN = (TKN - NH_4)/CH \qquad (6\text{-}2)$$

$$aP = (TOT\ P - PO_4)/CH \qquad (6\text{-}3)$$

in which

aC, aN, aP = carbon, nitrogen, and phosphorus-to-chlorophyll ratios

TOC = total organic carbon concentration of sample

TKN = total Kjeldahl nitrogen concentration of sample

NH_4 = ammonia concentration of sample

TOT P = total phosphorus concentration of sample

PO_4 = ortho phosphorus concentration of sample

CH = chlorophyll 'a' concentration of sample

Due to the presence of organic compounds which are not bound up in living algal biomass, Eqs. 6-1 through 6-3 will frequently yield over-estimates of the algal-composition ratios. To utilize this method, the minimum ratios obtained from analysis of a large number of samples should be selected.

This methodology provided a reasonable value for the phosphorus-to-chlorophyll ratio: aP = 0.001 mg/μg. The carbon and nitrogen fractions obtained were excessive, so the Redfield Ratios of N/P=7 and C/N=6 were utilized as a guide to obtain aN = 0.007 mg/μg and aC = 0.042

mg/μg. These values of aP and aN were employed in the model. The value of aC was further adjusted to 0.05 mg/ug in order to match the observed CBOD concentrations.

2) Nitrogen-Related Coefficients - The nitrogen-related coefficients employed in the calibration are presented in Table 6-6.

3) Phosphorus-Related Coefficients - The phosphorus-related coefficients employed in the calibration are presented in Table 6-7. It should be noted that very high ortho phosphorus settling rates are used around segment 9 where the STP effluent discharges into Aquia Creek. The settling rates are 1.0, 3.0, 2.0 and 1.0 m/day, respectively, for segments 8, 9, 10 and 11, and zero for all other segments. The use of these settling rates is necessary in order for the model predictions to match field measurements. The STP discharged a nearly constant rate of ortho phosphorus from May to September, 1981. The model simulation without settling produced a distinct peak on the ortho phosphorus distribution curve. However, none of the field measurements shows any local maximum. It was apparent that most of the ortho phosphorus from the STP either settled around segment 9 or even in the Austin Run before it reached the Aquia.

Several investigators (Mayer and Glass, 1980 Lake and MacIntyre, 1977 Parfitt, et al., 1975 Veith and Sposito, 1977) have demonstrated a loss mechanism by adsorption of phosphate to sediment particles. Experiments by Lake and MacIntyre (1977) indicated that phosphate and tripolyphosphate were readily adsorped to clays and estuarine sediments. They found that the adsorption was almost completed within the first three hours, and the adsorption was a linear function of initial phosphate concentration. Therefore, the use of high ortho phosphorus

TABLE 6-7. Phosphorus-Related Coefficients

Coefficient	Equation	Value	Source
Kp12	4-17,18	0.14/mg/l/day	calibration
Kp11	4-17	0.1 m/day	'
Khp	4-17,18	1.0 mg/l	'
BENP1	4-17	0.0 gm/m^2/day	'
Kp22*	4-18	0-3.0 m/day	'
BENP2	4-18	0.0 gm/m^2/day	measured
θp12		1.04	calibration
Frop	4-17,18	0.75	'

TABLE 6-8. CBOD- and DO-Related Coefficients

Coefficient	Equation	Value	Source
Kc	4-19	0.05/day	calibration
Ksc	4-19	0.0 m/day	calibration
Kro	4-21	3.93	see text
BENDO	4-20	1.1-2.0 gm/m^2/day	measured
θbod		1.047	calibration

settling rate is in consistent with geochemical behavior of phosphate. In the modeling study of Potomac water quality, Thomann and Fitzpatrick (1982) found it necessary in model verification runs to use a high settling rate of 20 to 15 ft/day near Blue Plain STP in order to model ortho phosphorus successfully.

4) CBOD- and D.O.-Related Coefficients - The coefficients related to CBOD and D.O. and employed in the calibration are presented in Table 6-8. The coefficient $K_{ro} = 3.93$ is the metric equivalent of $K_{ro} = 12.9$ given by O'Connor and Dobbins (1958) for the English system of units.

5) Calibration Results - Field data and model predictions for the August, 1981, intensive survey are plotted against distance from the creek mouth in Figure 6-2. The mean and range of observations and predictions are shown for organic nitrogen, ammonia nitrogen, nitrite-nitrate nitrogen, ortho phosphorus, total phosphorus, chlorophyll'a', $CBOD_u$, and dissolved oxygen.

Good agreement is achieved between predicted and observed concentration distributions along the creek axis. Discrepancies are often attributable to the objectives of consistency between the calibration and verifications rather than to failure to curve-fit the model to the data.

Significant difference does exist between the model prediction and the data. The model underpredicts concentrations of CBOD and organic nitrogen. This may be attributable to the accuracy of the nonpoint source loads. Table 6-3 clearly indicated that the NVPDC predictions of nonpoint loads of CBOD are always lower than field measurements. The comparison of organic nitrogen is less conclusive,

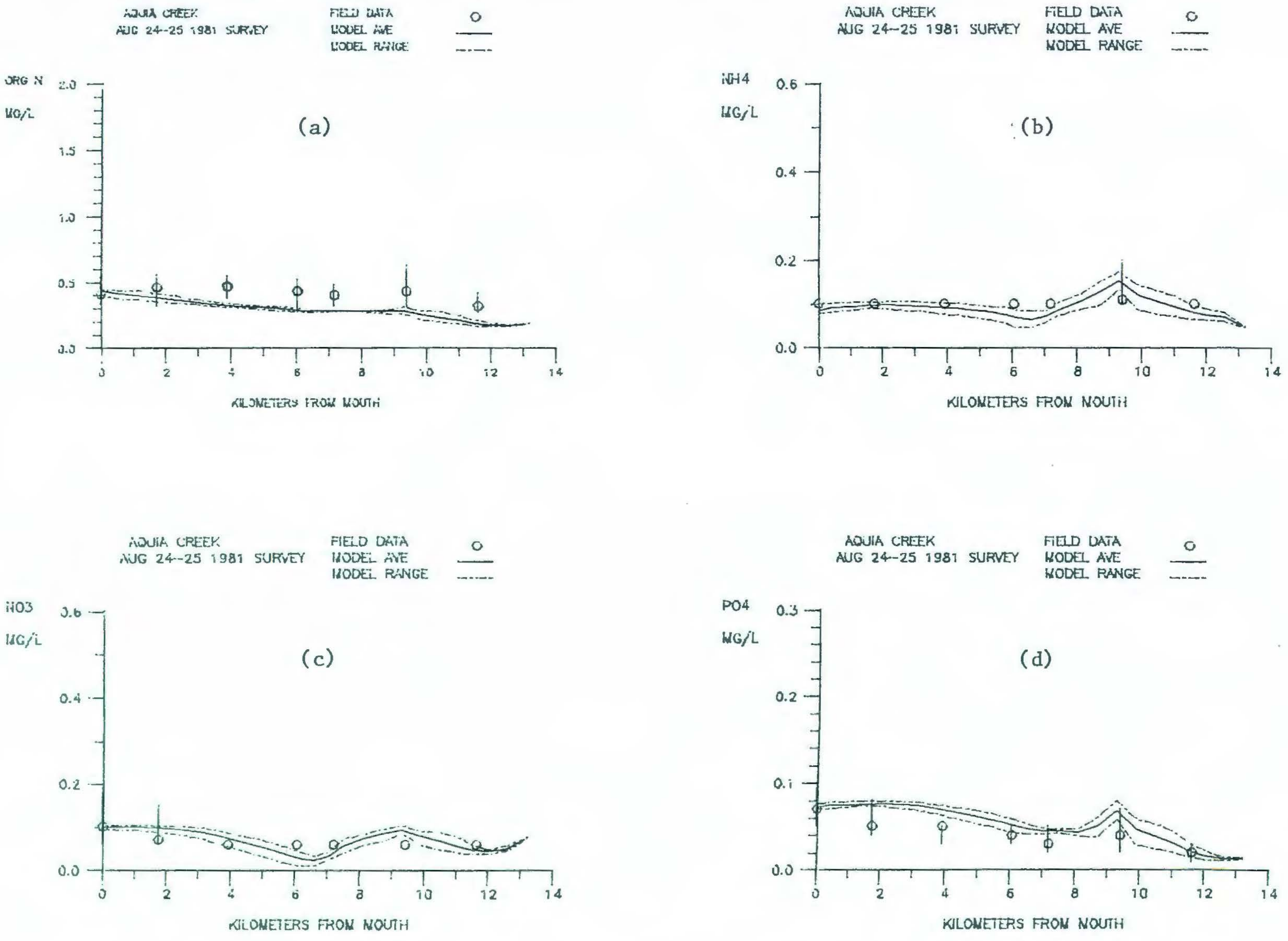


Figure 6-2. Comparisons of model calibration with intensive data.

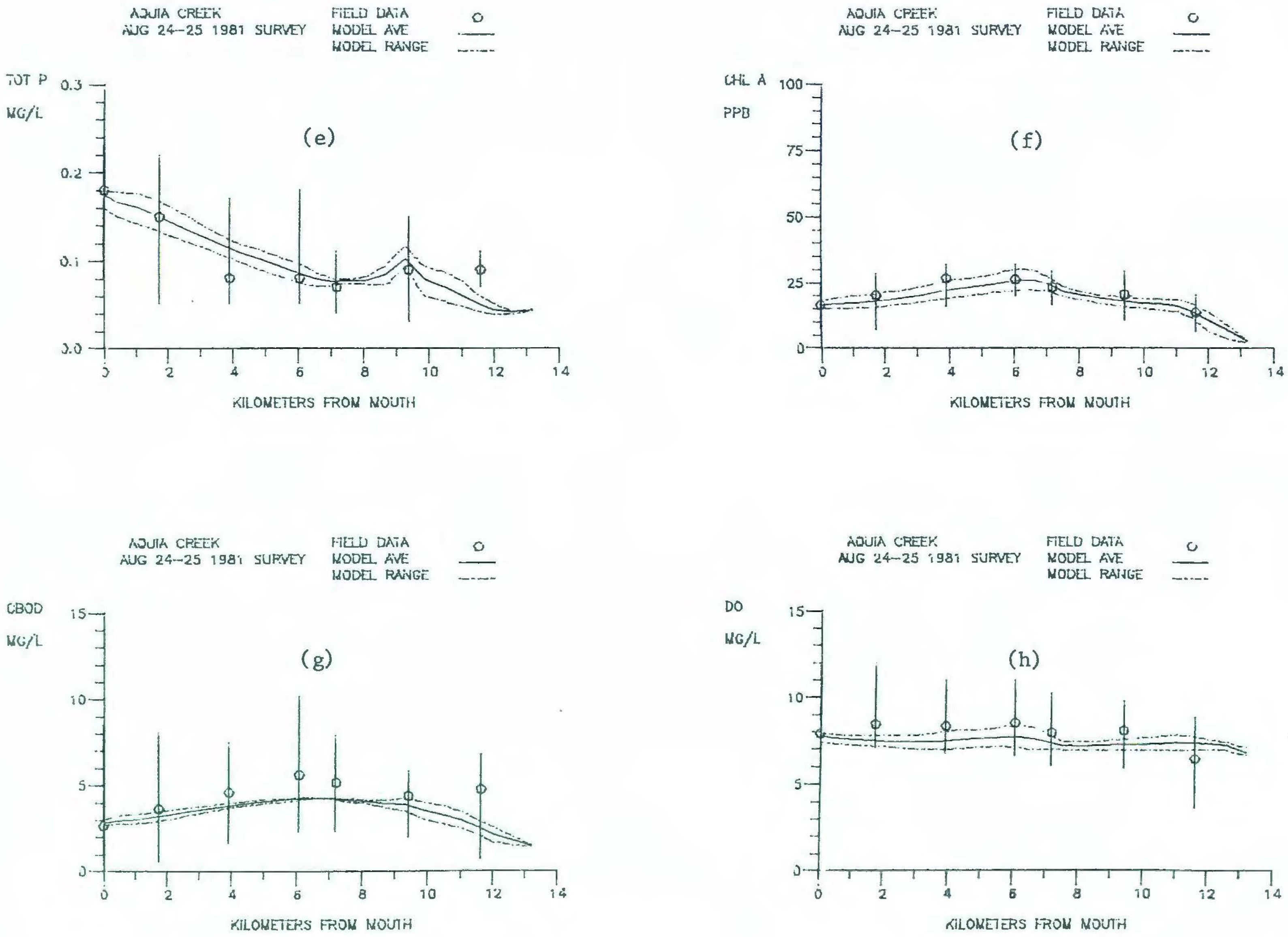


Figure 6-2. (Cont'd)

even though it happens more often that field measurements are higher than NVPDC predictions.

It should be noted that both the model predictions and field data for ammonia and nitrite-nitrate nitrogen (Figures (b) and (c)) are at the laboratory detection limits. The data points in the figures indicate the maximum possible concentrations, rather than actual values.

E. Verification with the Slackwater Surveys

The objective of verification is not to fit the model to the data through evaluation of various coefficients. Rather, the purpose of verification is to test that previously evaluated coefficients are correct and consistent. This is done by comparing model predictions with observations collected independently of the calibration survey and under different ambient conditions and external loads. In the verification, the long-term predictive ability of the model is tested through comparisons of model predictions with observations collected in the June 11 through August 25 series of slackwater and intensive surveys. The model simulates the summer season in a single, two and one-half month run using the June 11 observations as initial conditions and providing predictions for comparison with data collected in the four subsequent slackwater surveys (Table 3-2), and the intensive survey. The May 26 and September 21 slackwater surveys were not included in the verification because of the lack of tide data and a reported sludge spill of unknown magnitude on September 15. The time series tide data at creek mouth are required to run the hydrodynamic model. Details of the verification procedure and results are presented in the remainder of this chapter.

1) External Inputs and Ambient Conditions - Evaluation of external inputs and ambient conditions for the seasonal run is problematical in that daily measures of stream flow, temperature, boundary conditions, etc., are unavailable. These were measured only in conjunction with the slackwater surveys. Thus there are inter-survey gaps of approximately two-weeks duration in the data base. These gaps were filled by assuming temperature, downstream boundary conditions and turbidity observed in the slackwater surveys were constant during the interval beginning one week prior to the survey and extending one week after. That is temperature, downstream boundary conditions and extinction coefficients are modelled as step functions with the duration between steps equal to the interval between surveys.

2) Constants and Coefficients - All constants and coefficients employed in the seasonal verification are identical to those in model calibration run.

3) Verification Results - Results of the seasonal verification, presented as plots of predictions and observations along the creek axis, are shown in Figure 6-3. Except for figures (i) and (j), the figures indicate the instantaneous data points and the range of predicted concentrations in the twenty-four-hour interval centered on the time of the survey. The data points in figures (i) and (j) are average values of the intensive survey.

In evaluating the verification results, consideration must be given to the sparcity and variability of the observations and to the potential effects of processes active in the prototype but not included in the model. Random spatial and temporal variability in the data manifests in the form of extreme data points which the model cannot

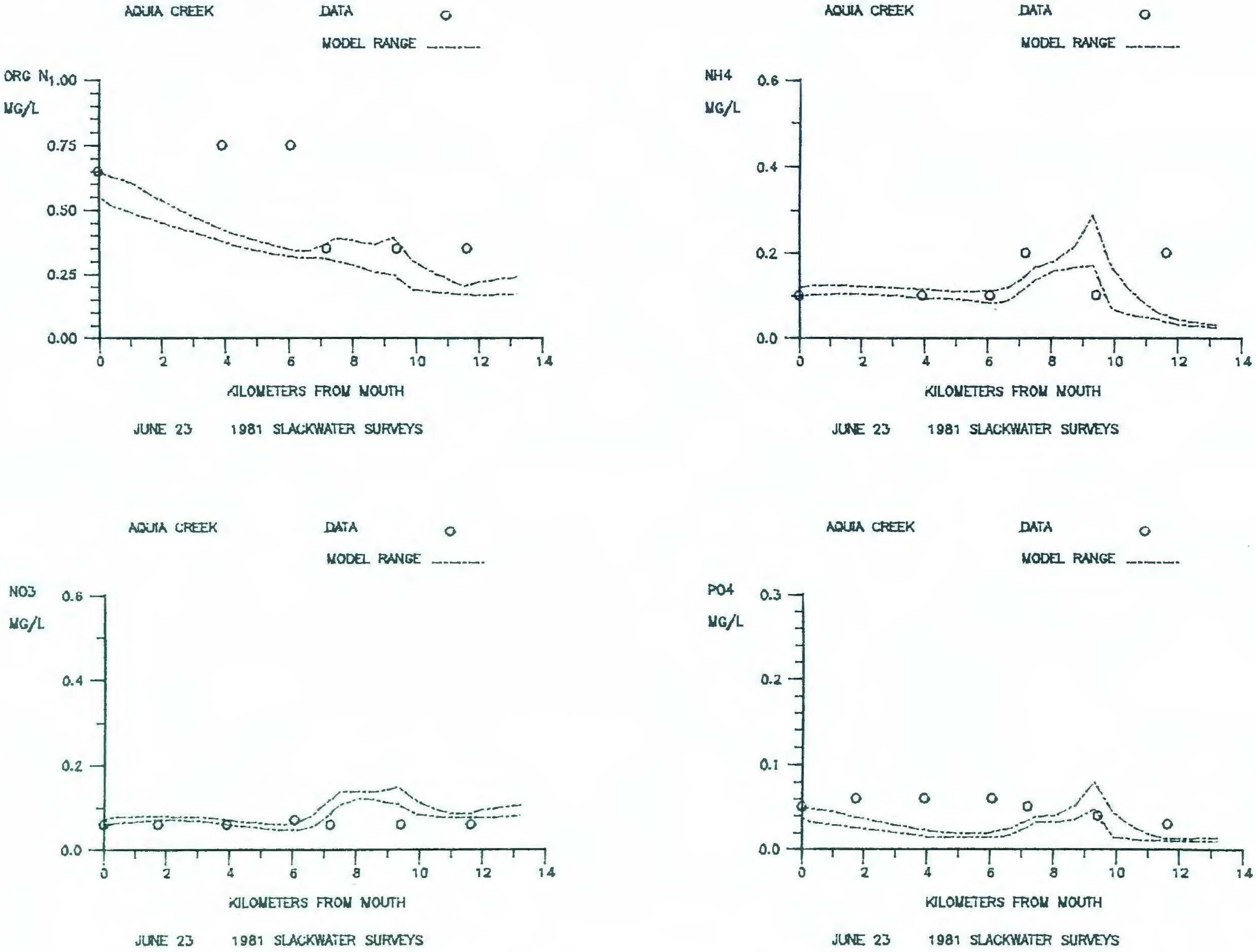


Figure 6-3a. Comparison of model verification with slackwater data.

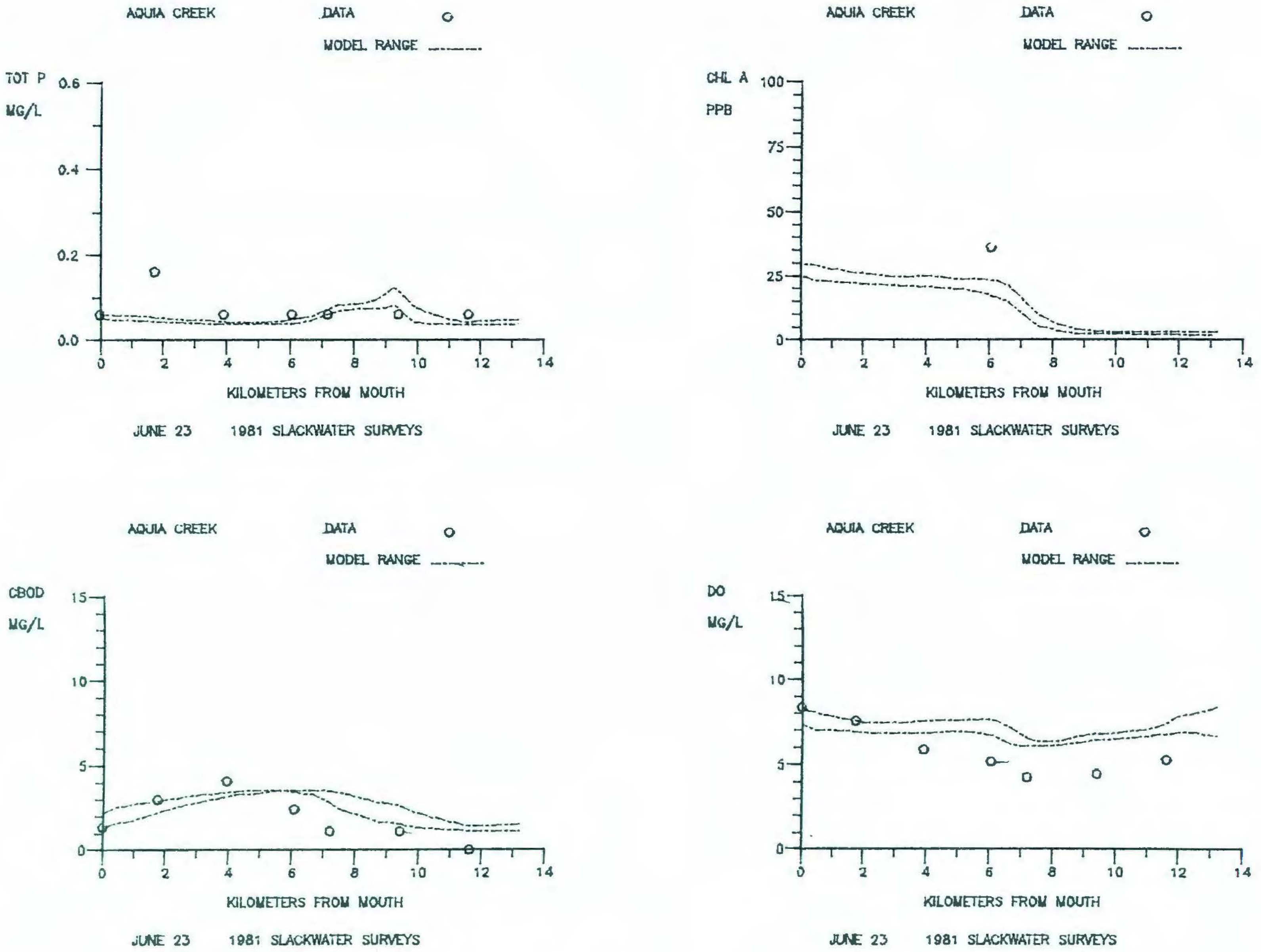


Figure 6-3b. (Cont'd)

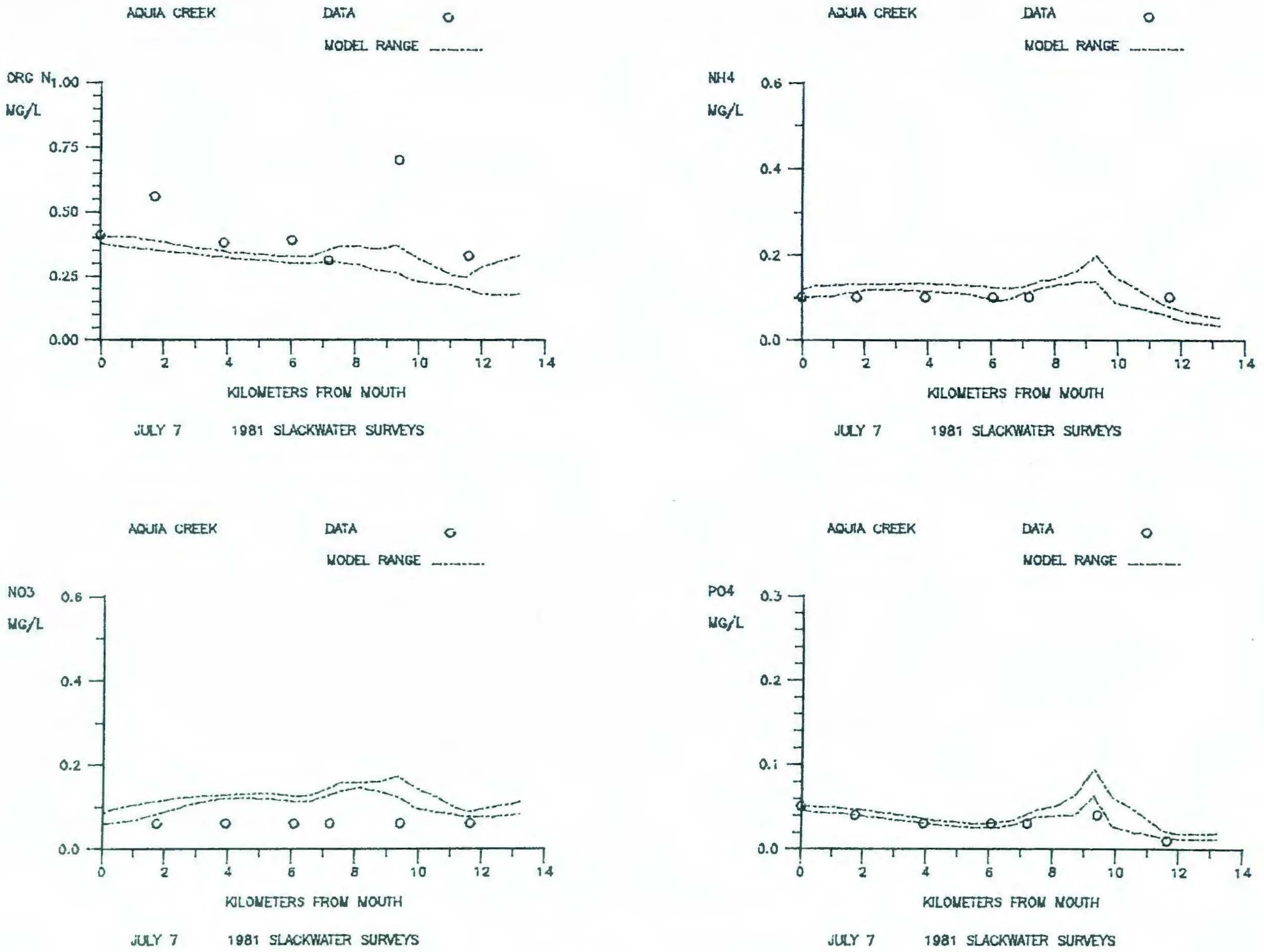


Figure 6-3c. (Cont'd)

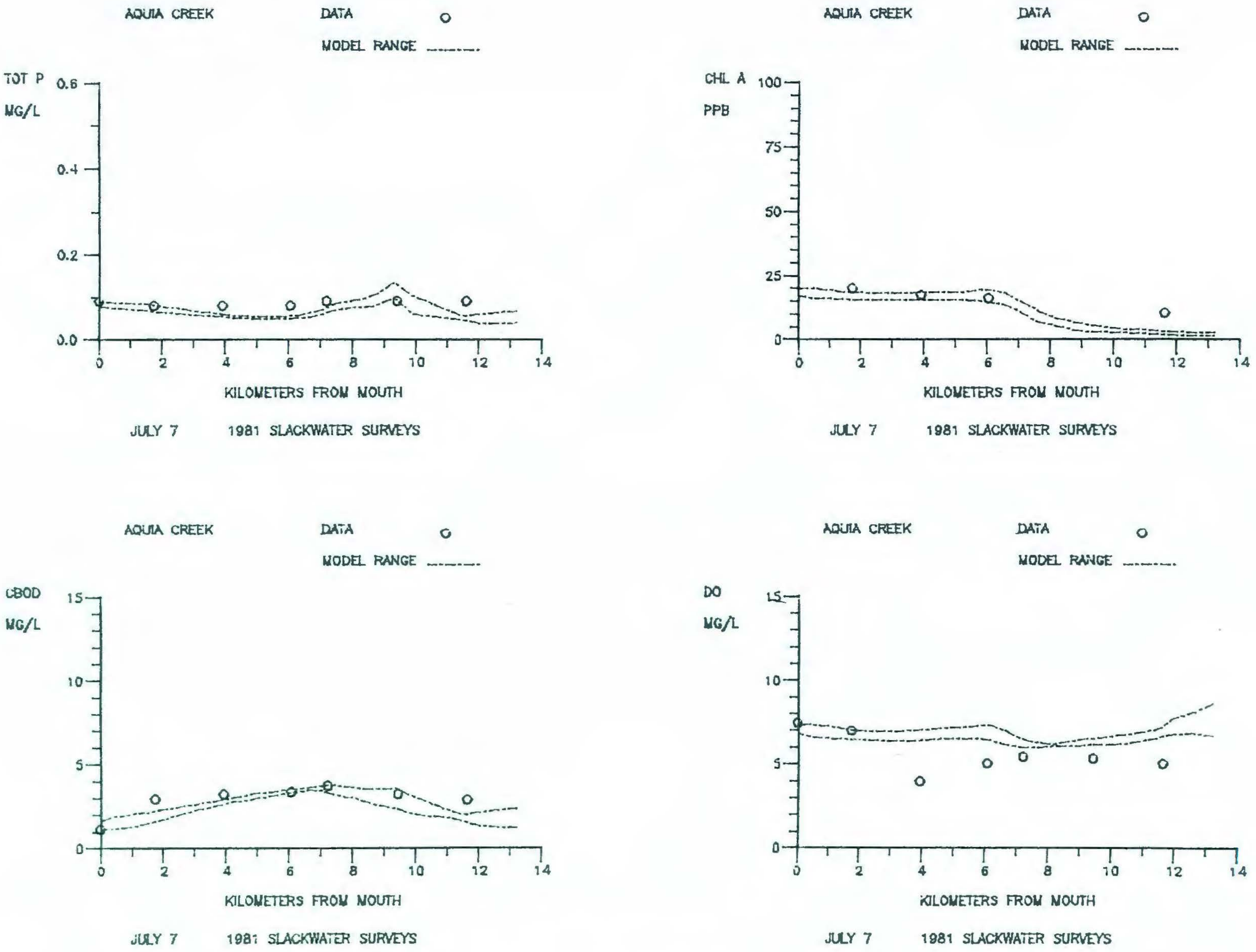


Figure 6-3d. (Cont'd)

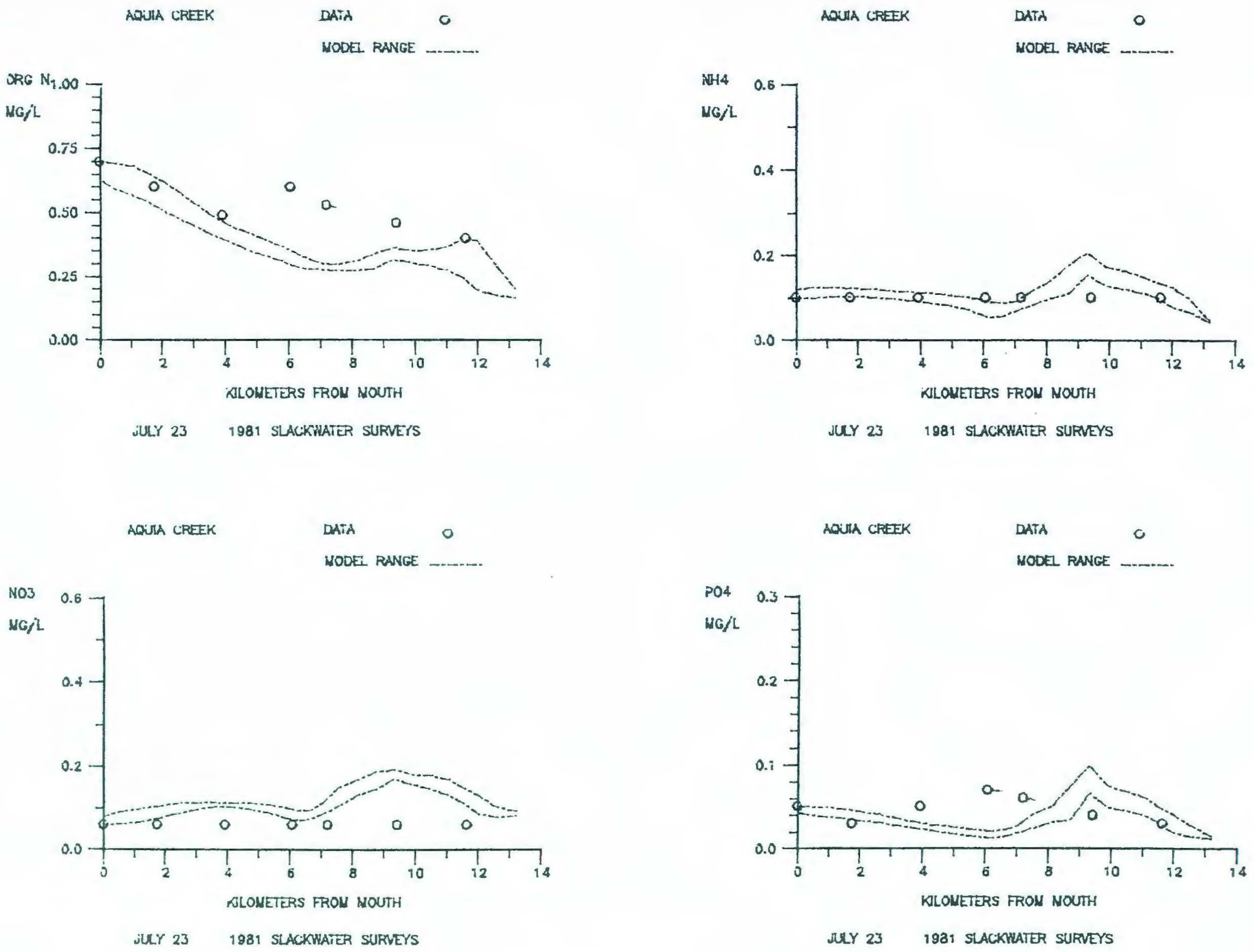


Figure 6-3e. (Cont'd)

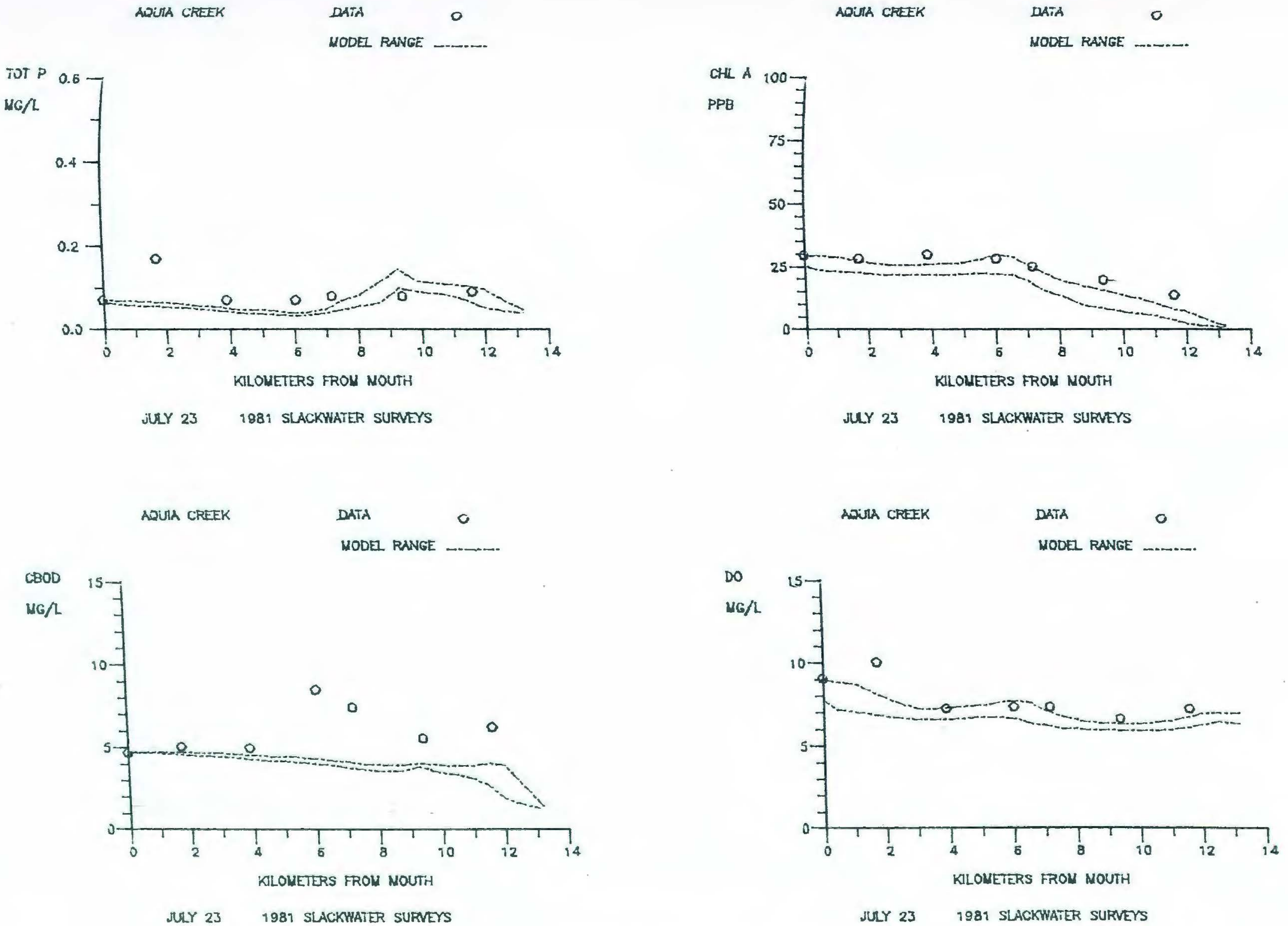


Figure 6-3f. (Cont'd)

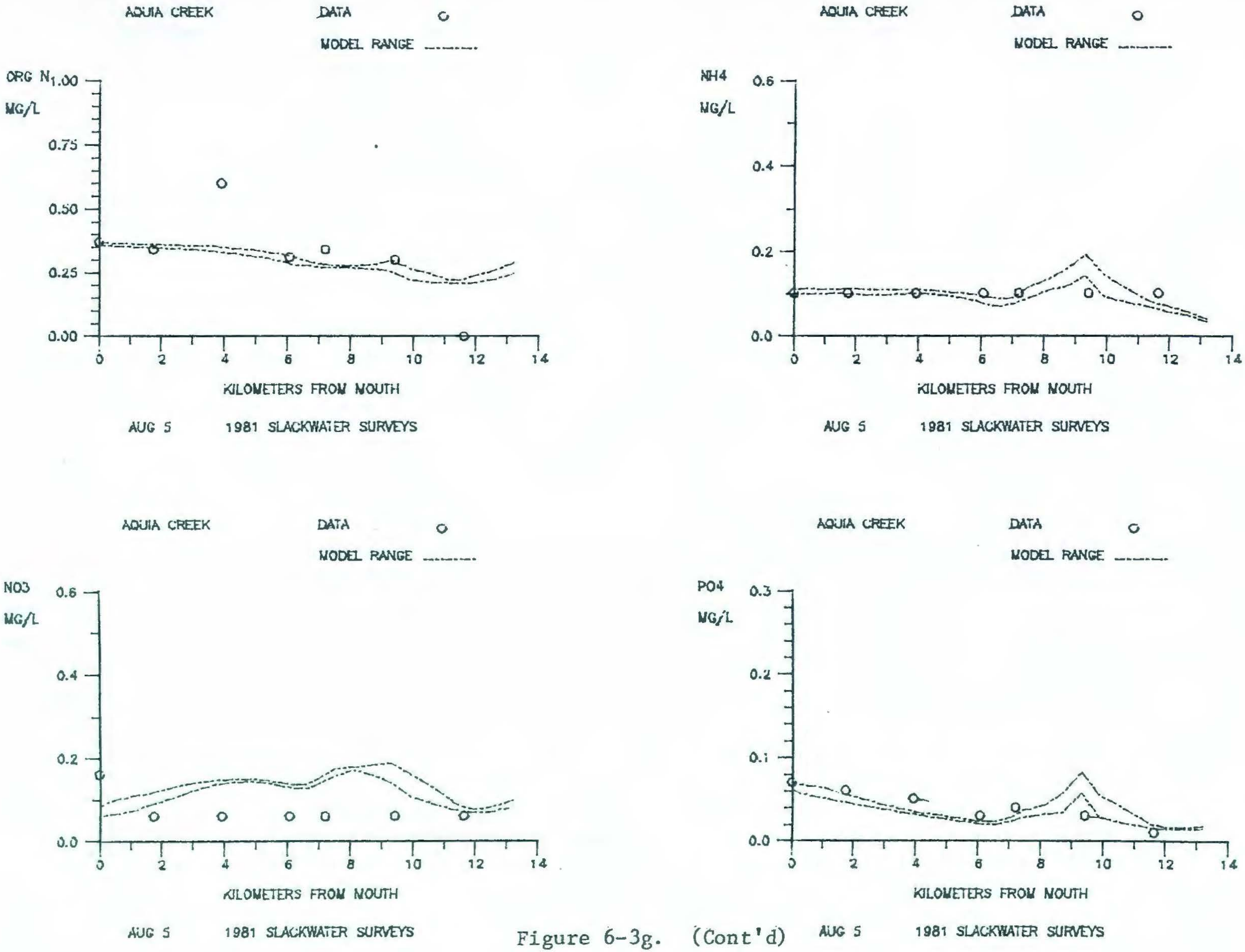


Figure 6-3g. (Cont'd)

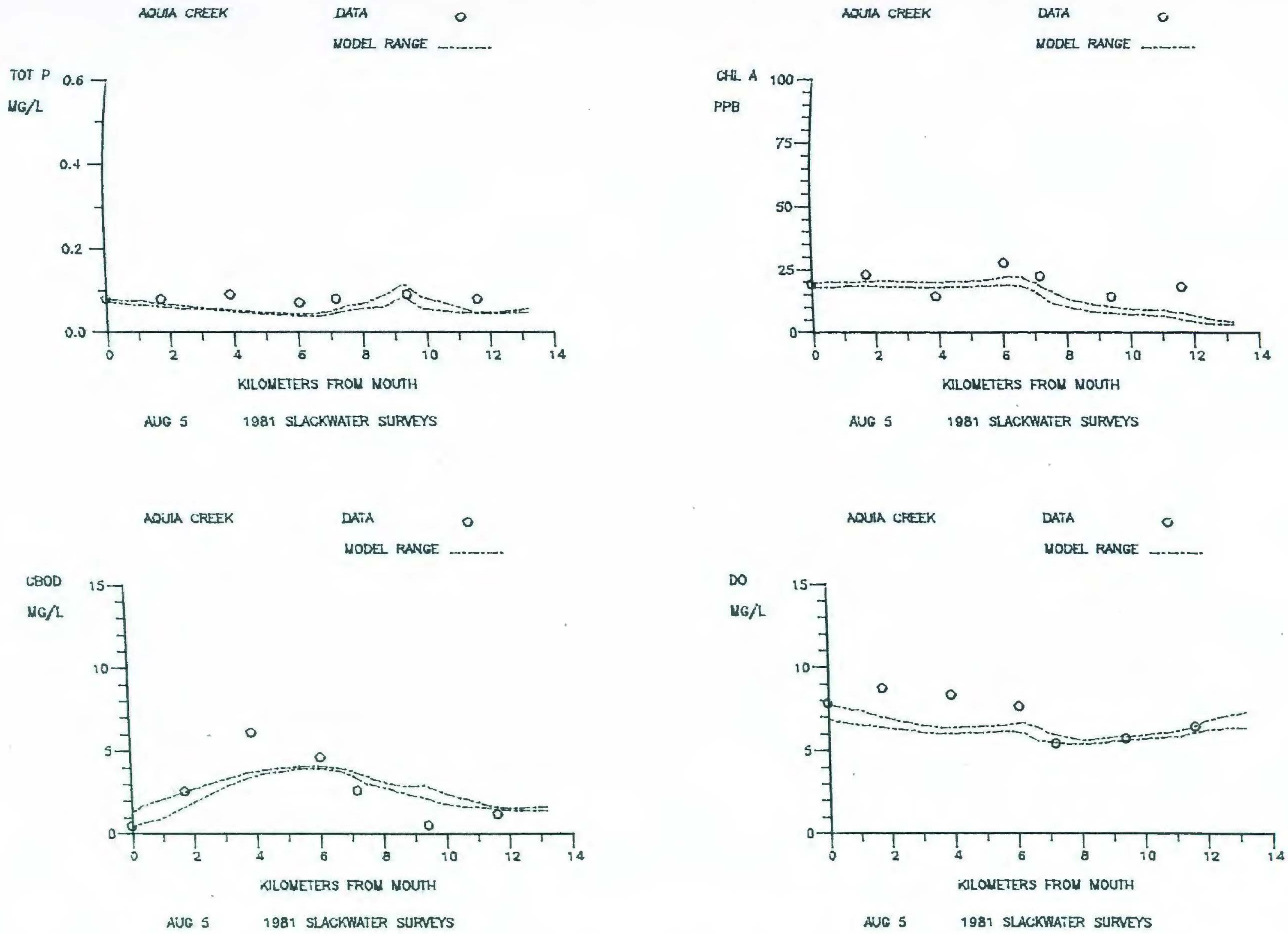


Figure 6-3h. (Cont'd)

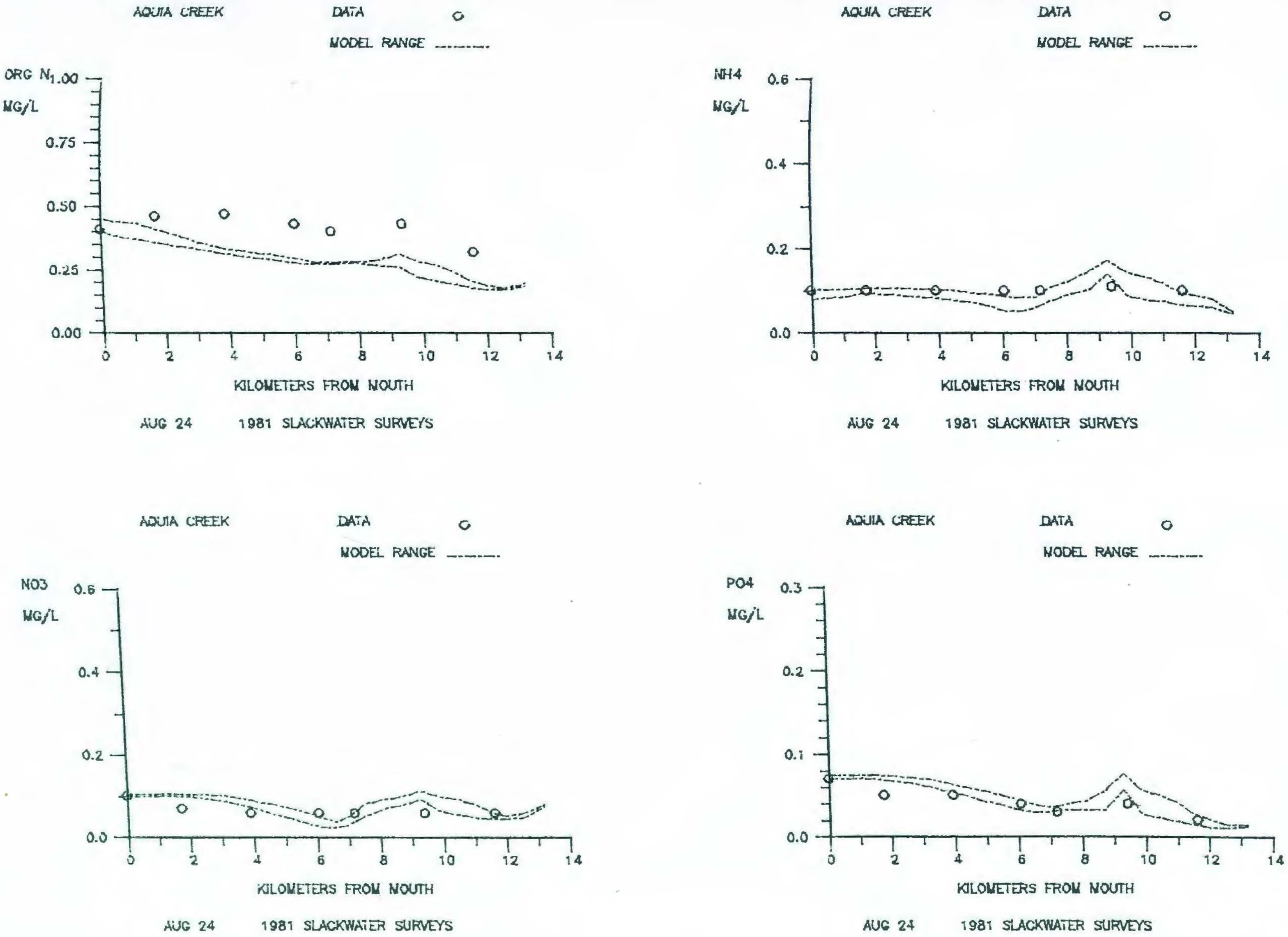


Figure 6-3i. (Cont'd)

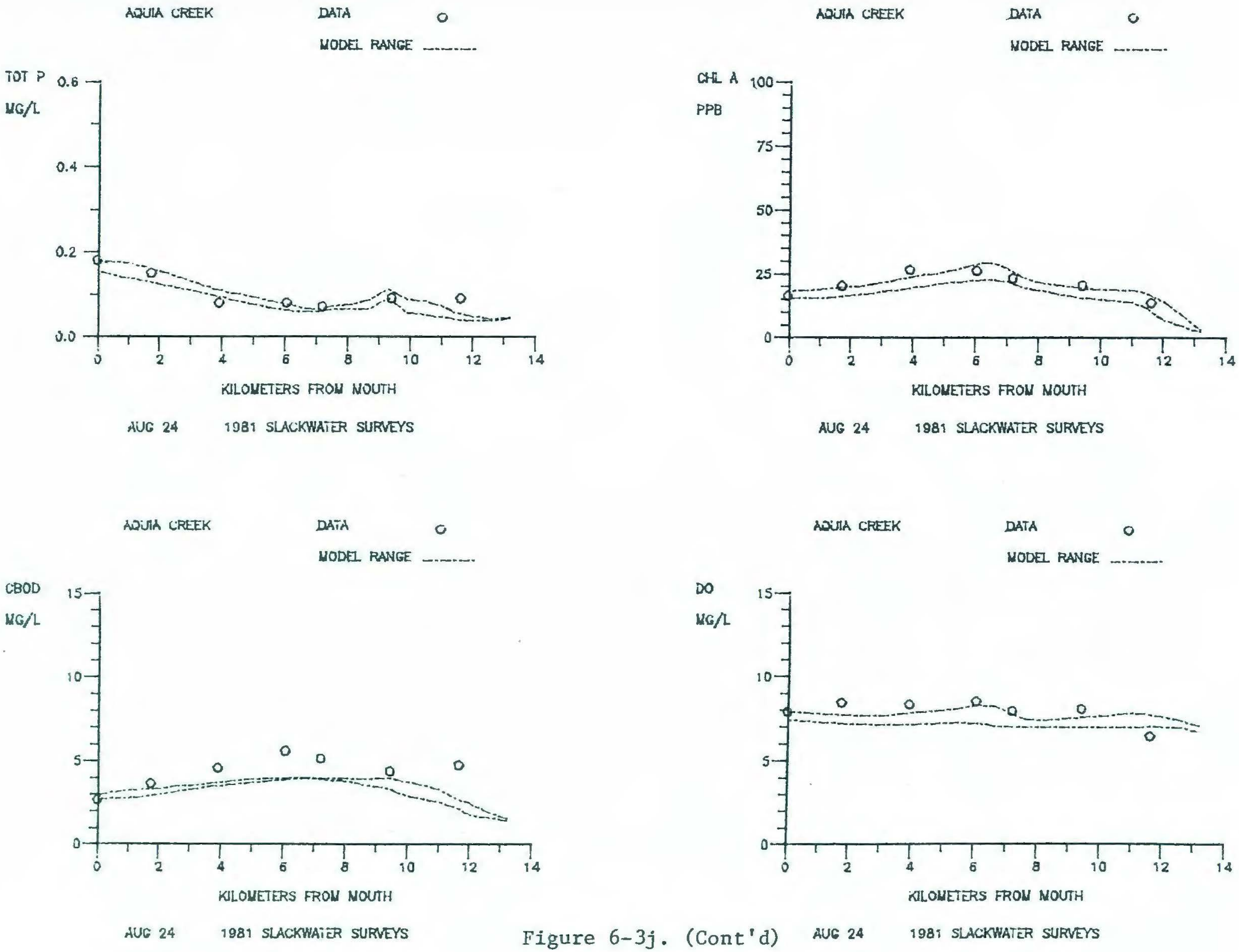


Figure 6-3j. (Cont'd)

replicate. Prototype processes not included in the model are, for example, wind events which push creek water out into the Potomac or cause dilution of the creek with river water.

While the model will not reproduce individual data points, it is expected to represent the spatial trends and approximate magnitude of the observations in each survey. Based on these criteria, the seasonal run is a credible verification of the ability of the model to simulate the long-term behavior of the creek, although discrepancies between the observations and predictions do occur.

A notable deviation of the predictions from the observations is the ortho phosphorus concentrations from km 3 to km 6 on June 23 and July 23. The model predicts lower concentration in this reach of the creek. The values of field data are generally low throughout the creek at all surveys. Since the measured concentrations are close to laboratory detection limits, a slight error in determining the concentration and/or in benthic flux measurement could account for the discrepancy. The effect of benthic flux will be discussed further in the next chapter.

Another area of discrepancy is the dissolved oxygen concentrations on June 23 and July 7. The model predicts higher than observed values in most parts of the creek except near the mouth. Both days are immediately following storm runoff events, the inaccuracy of nonpoint source predictions may cause this discrepancy. Again, nearly all of the ammonia and nitrite-nitrate nitrogen data and predicted values are at the limit of laboratory detection.

A second view of the seasonal verification is presented in the time-series plots of Figure 6-4 which illustrate creek average conditions throughout the season for each water-quality parameter. Data points are the average of all samples collected in each survey while the model output is the daily-average of all model segments except those at very upstream reach where no field data are available. These plots are advantageous in that random variability in the data is, to some extent, averaged out and temporal trends in the predictions and observations are visible.

Interpretation of the time-series plots provides interesting insights into the effects of nonpoint runoff on the water quality in the creek. Organic matter, CBOD, organic nitrogen and, to a lesser extent, total phosphorus, increase in the creek in response to storm water runoff around June 20, July 4, July 27, and August 12. On the contrary, chlorophyll concentrations decrease due to the flushing by storm water.

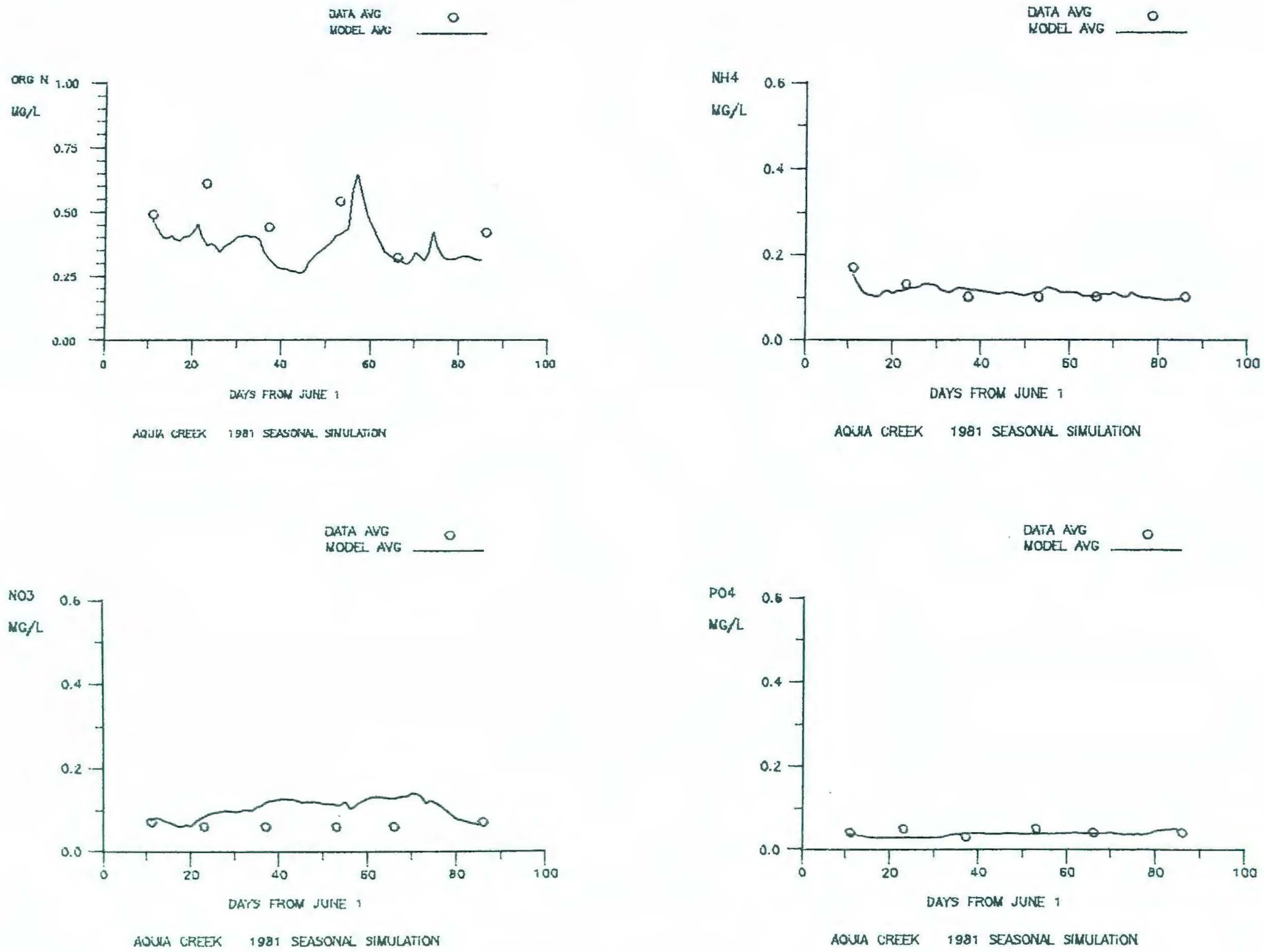


Figure 6-4. Time-series plots of seasonal verification.

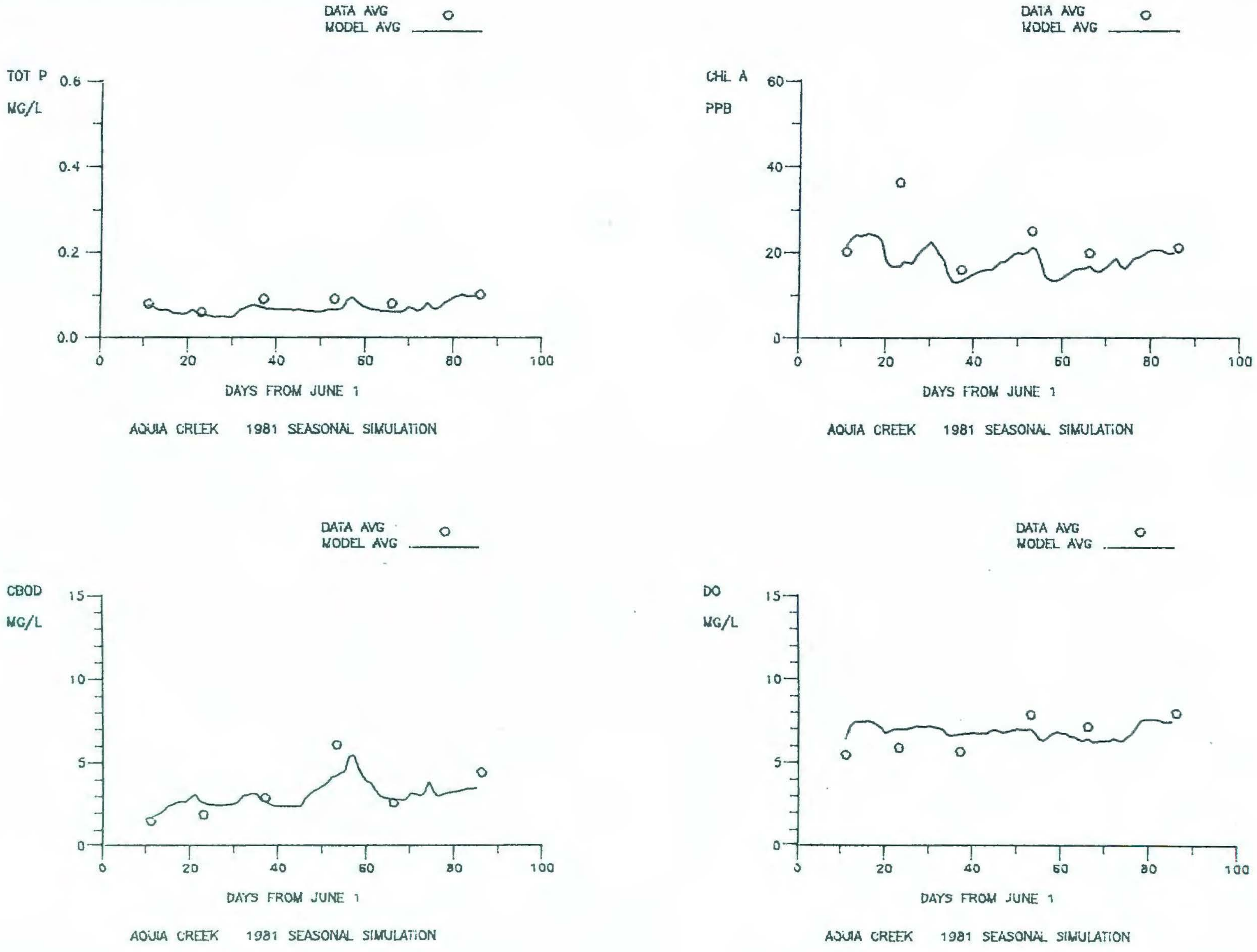


Figure 6-4. (Cont'd).

CHAPTER VII. SENSITIVITY ANALYSIS

Through sensitivity analysis, a primary use for the calibrated and verified model, the modeller can examine the response of the model and the prototype to alterations in external loading, ambient conditions, or internal biogeochemical processes.

Sensitivity analysis on the model itself may be intended to examine the effect on predictions of the evaluation of crucial rates and coefficients. If a small change in a coefficient produces a large alteration in results, then the coefficient must be carefully evaluated. If alterations in a coefficient produce little effect on the output, then the value can be assigned with less concern that model predictions will be adversely effected by deviations from the 'true' value of the coefficient. Model sensitivity analysis can also be used to justify the employment of calibration values which are outside the normally-accepted range or otherwise appear questionable.

A second major use for sensitivity analysis is to explore, through experiments conducted on the model, factors which influence water quality in the prototype. In alternate model runs, the effects on the system of eliminating point-source and nonpoint-source loadings might be examined, for example. Experiments of this nature would be difficult or impossible to conduct on the prototype.

A. Sensitivity of the Water Quality Model

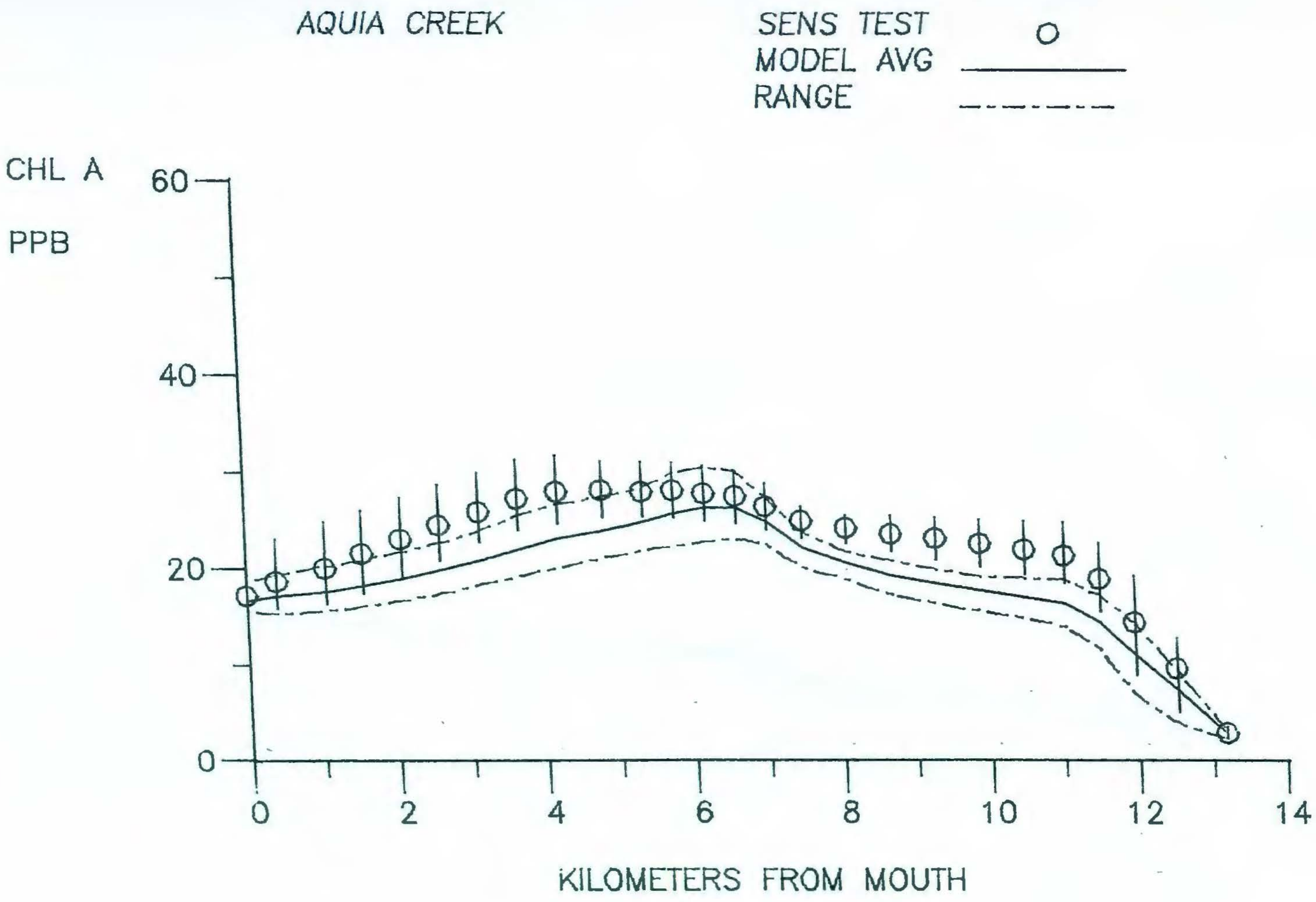
Evaluation of the chlorophyll growth rate, Kgr, is crucial to the validity of the model. Thus this coefficient is a prime candidate for sensitivity analysis. The analysis is conducted by running the model with all parameters as in the calibration run except for the growth rate. The revised model predictions are then compared to the calibrated model.

The sensitivity of the predicted chlorophyll concentrations to the evaluation of the chlorophyll growth rate is examined by alternately increasing or decreasing the rate by 25 percent. That is, value Kgr = 2.5/day or Kgr = 1.5/day is employed. Results of the analysis are presented in Figure 7-1 (a) and (b). The figures compare the average and range of model prediction from sensitivity runs with those from calibrated results. Figure (a) shows that increasing phytoplankton growth rate to 2.5/day changes the chlorophyll concentration only slightly in most parts of the creek. This is due to the fact that the creek is nutrient limited. Figure (b) shows that decreasing growth rate greatly reduces not only the average chlorophyll concentration but also the range of diurnal variation.

In a second model run, the suitability of nitrification rate, Kn23, is tested. The nitrification rate used for model calibration was 0.3/day at 20^{o}C. A model run was conducted with nitrification rate of 0.1/day. The results are presented in Figure 7-2. The figure shows that the reduction in nitrification rate affects only the transfer of ammonia nitrogen to nitrate nitrogen. It has no noticeable effect on chlorophyll concentration.

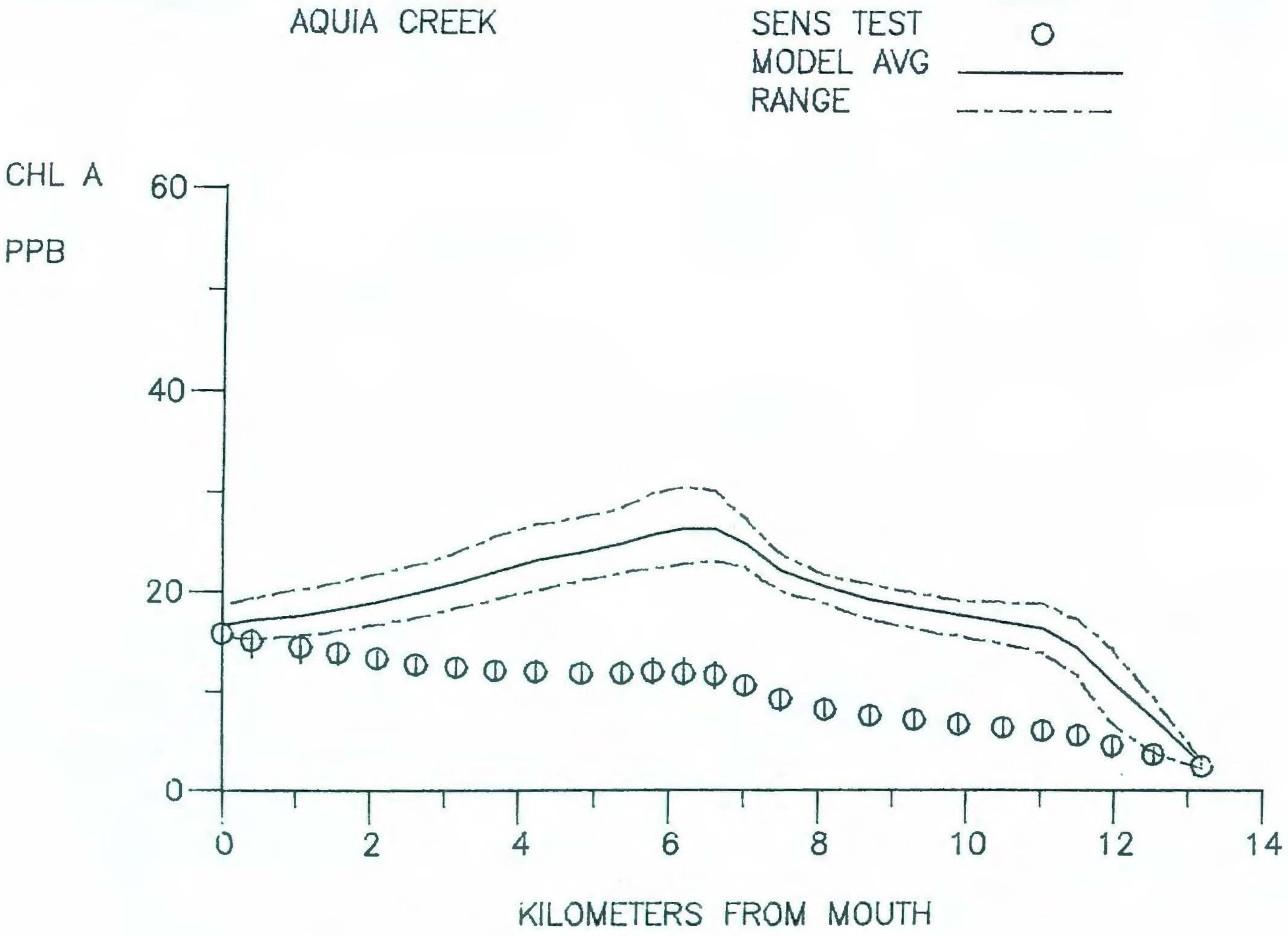
B. Sensitivity of the Prototype

Sensitivity analyses directed towards the prototype are conducted in a manner similar to the analyses directed towards the model. In these analyses, however, attention is devoted primarily to the external



(a) GRO. RATE=2.50

Figure 7-1a. Sensitivity of model results to chlorophyll growth rate.



(b) GRO RATE=1.5

Figure 7-1b. (Cont'd).

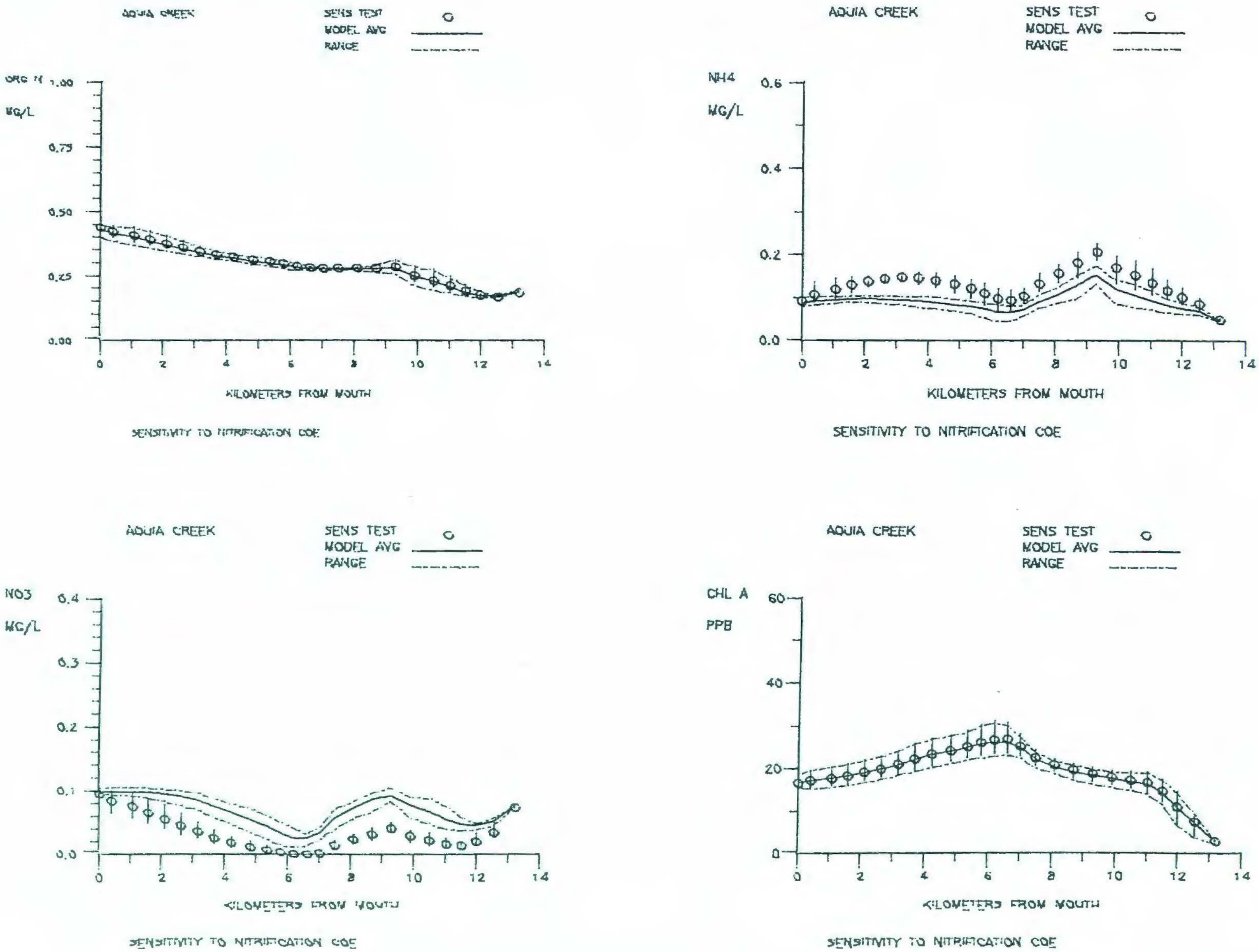


Figure 7-2. Sensitivity of model results to nitrification rate.

loads and ambient conditions which determine prototype water quality rather than to examination of the model coefficients.

It should be clearly noted that the results of subsequent sensitivity analyses are not precise predictions of prototype behavior under alternate sets of conditions. The variability of natural systems and the effects of random events may act to produce results which would differ from the predictions. The model results should be viewed as best estimates of the conditions to be expected if all external and internal processes remain at their calibrated levels except for the sensitivity parameters.

Sensitivity analyses are again based on the August, 1981, calibration period. This base condition is used for comparison with predictions obtained from the sensitivity parameters.

The sensitivity analyses are directed towards examining those factors which enhance or limit the algal population. These include sources of the nutrients, nitrogen and phosphorus, and the influence of light extinction.

1) Point-Source Nitrogen - The effect of nitrogenous nutrients discharged from the STP on the Aquia Creek system is examined in two model runs, one in which all forms of nitrogen are eliminated and the other in which the ammonia nitrogen is doubled. The results are compared with predictions of calibrated model in Figure 7-3. It can be seen that the effect of point source discharge on nitrogen distribution is confined to a 7 km reach of the creek. The maximum increase and decrease of chlorophyll concentration are about 3 μg/l and 6 μg/l, respectively.

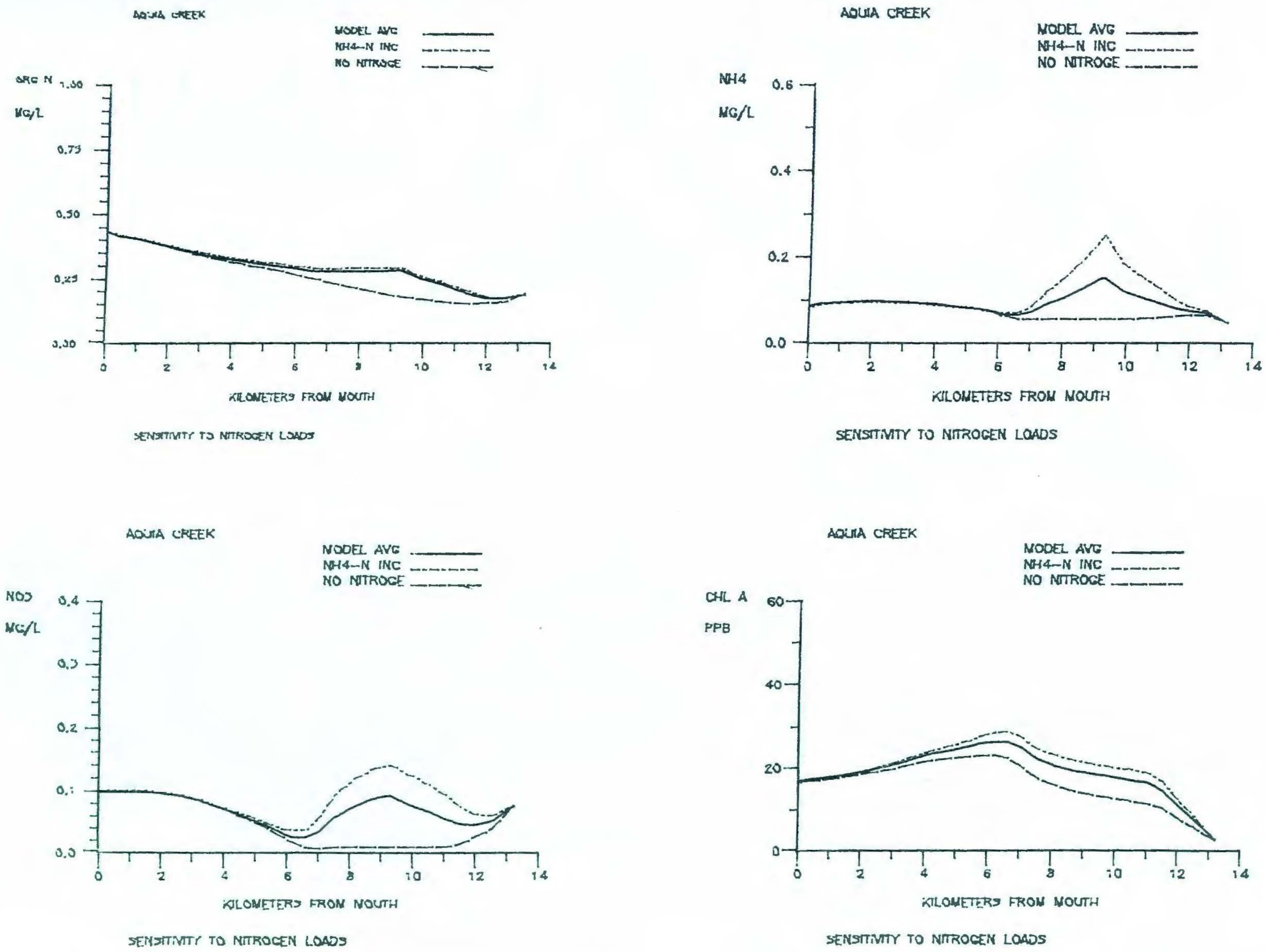


Figure 7-3. Sensitivity of the creek to point-source nitrogen.

2) Point-Source Phosphorus - The effect of phosphorus discharged from the STP is examined in a way similar to that of nitrogen. Two model runs are conducted, one in which both forms of phosphorus are eliminated and the other in which ortho phosphorus is doubled. Results are presented in Figure 7-4. Although the ortho phosphorus concentration in the creek responds proportionally to the increase in point source discharge, it has virtually no effect on chlorophyll concentration. Apparently, there is not enough nitrogen to support further algal growth. On the other hand, the elimination of point source phosphorus reduces the chlorophyll concentration in the upper reach of the creek.

3) Point Source as a Whole - Two sensitivity runs are made to examine the effects of point source as a whole. Except for the flow rate and dissolved oxygen concentration, all loadings are either eliminated or doubled in the sensitivity runs. Results are presented in Figure 7-5. The impacts on the water quality in the creek are mainly confined upstream of kilometer 7, where the creek expands abruptly (Figure 2-1).

4) Benthic Ammonia Flux - Benthic nutrient fluxes are becoming recognized as important nutrient sources for phytoplankton. The role of these fluxes in Aquia Creek is examined by eliminating or doubling the benthic sources of ammonia nitrogen. Results are shown in Figure 7-6. It can be seen that the elimination or doubling of benthic flux of ammonia nitrogen has significant effect on the chlorophyll concentration. This is because the system is nitrogen limited.

5) Benthic Phosphorus Flux - Field measurements suggest that the benthic flux of ortho phosphorus are negligibly small. Zero flux is

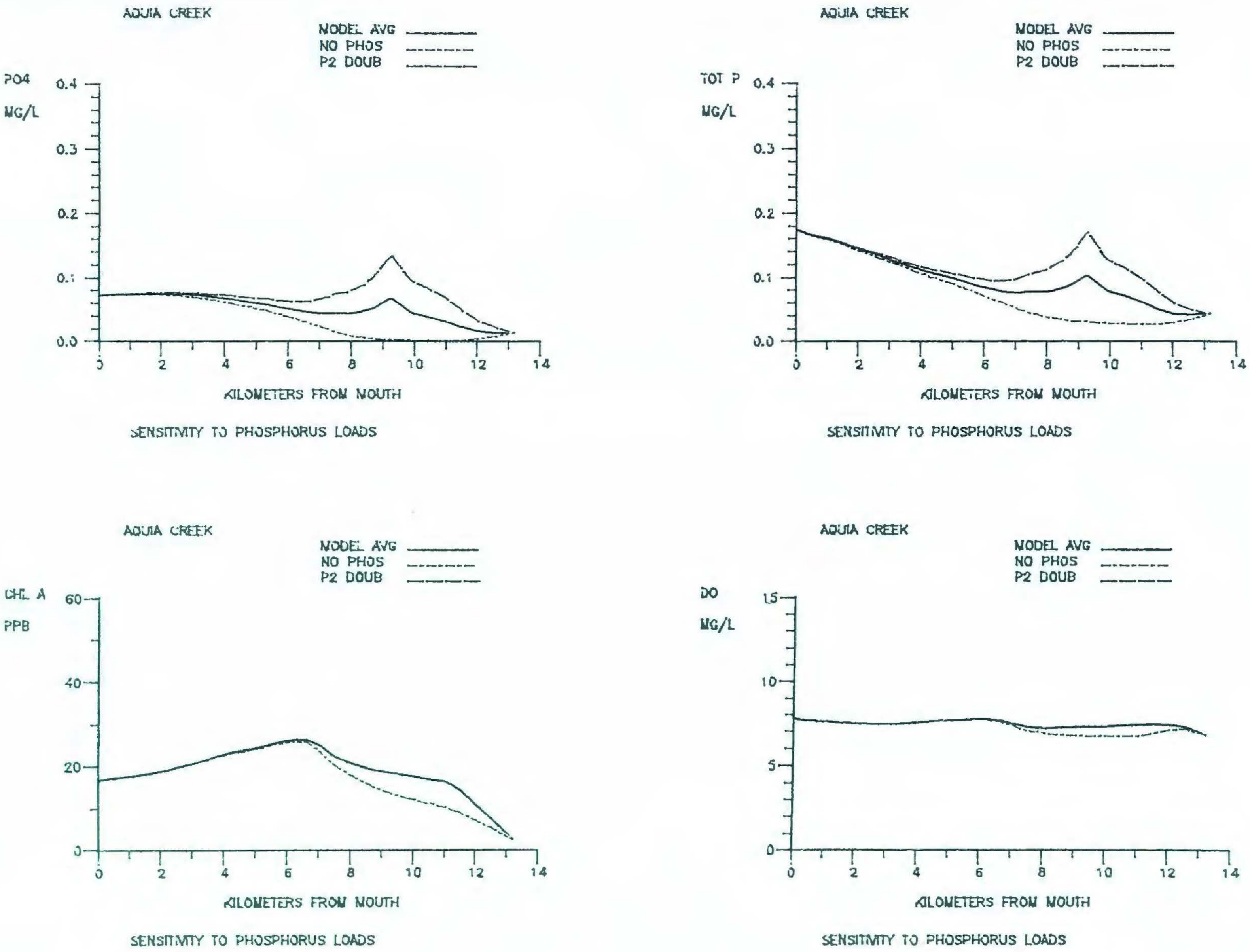


Figure 7-4. Sensitivity of the creek to point-source phosphorus.

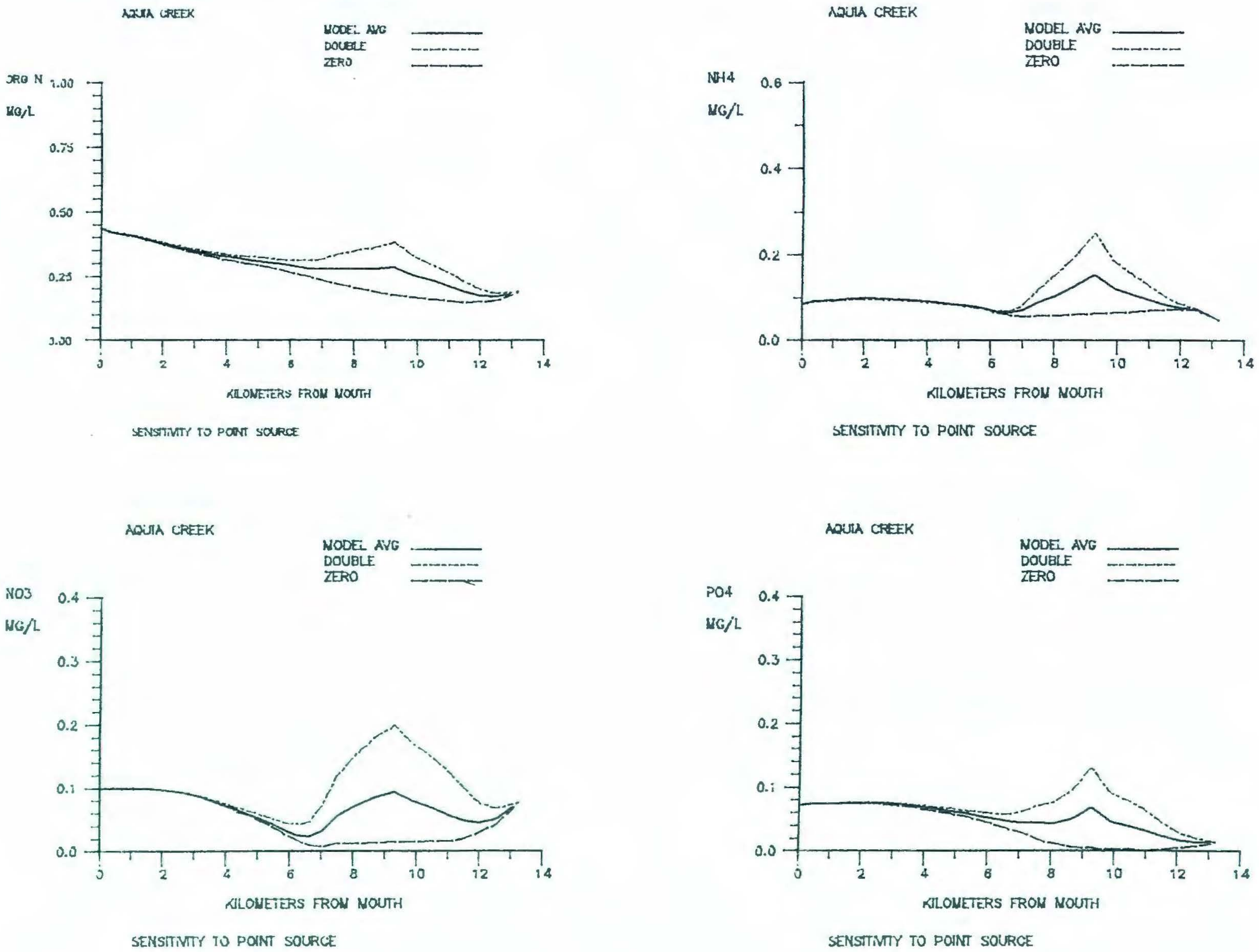


Figure 7-5. Sensitivity of the creek to point-source.

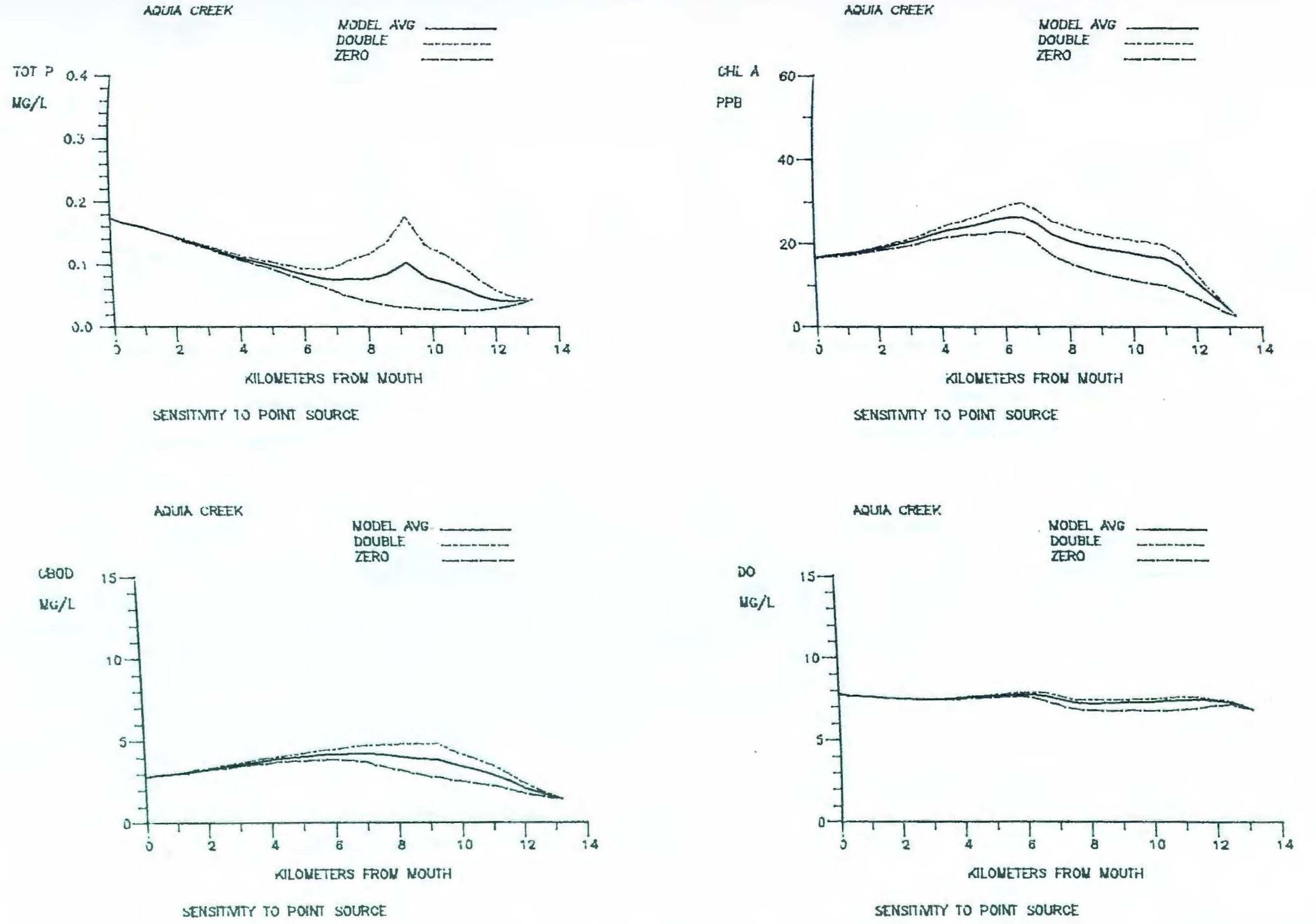


Figure 7-5. (Cont'd).

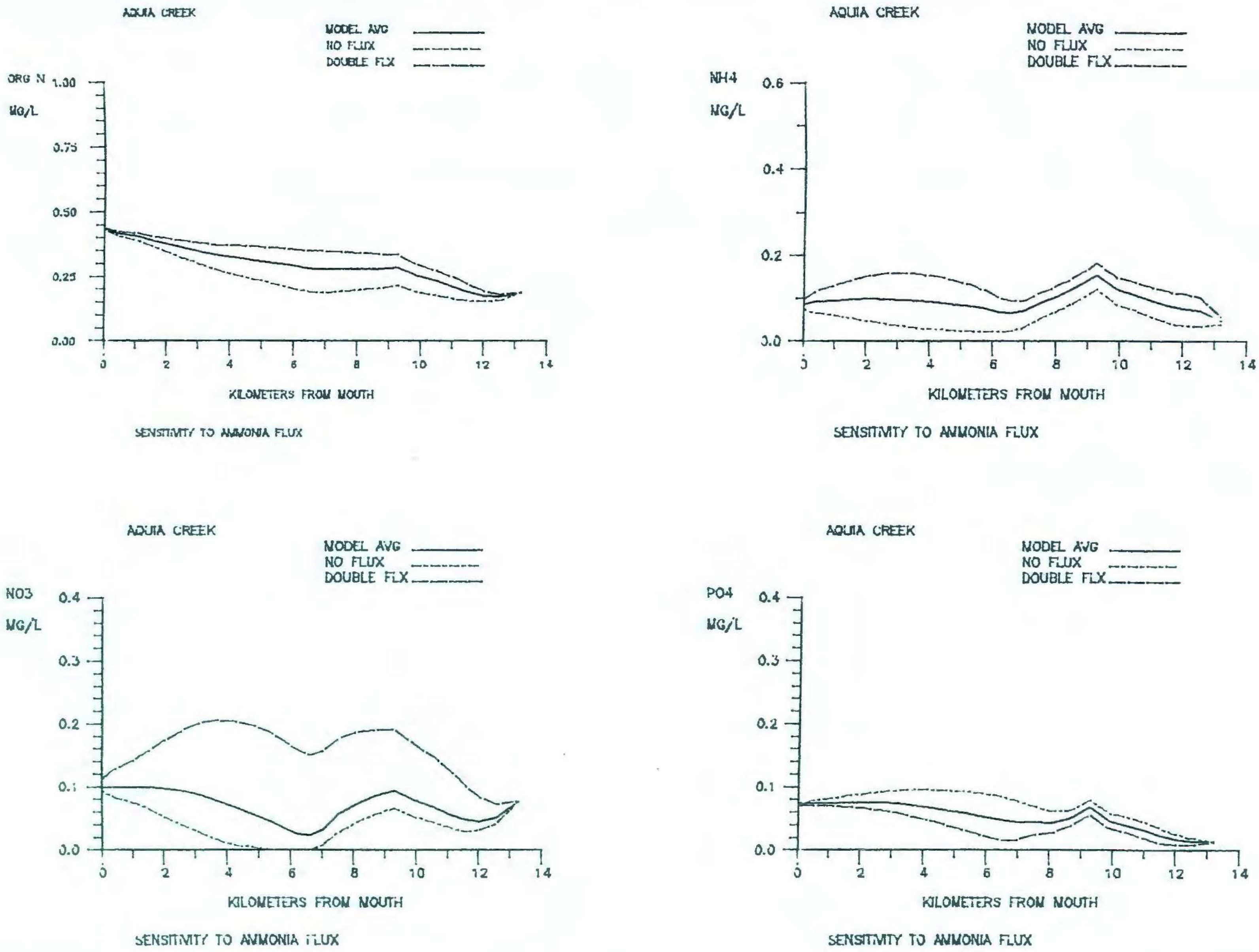


Figure 7-6. Sensitivity of the creek to benthic ammonia flux.

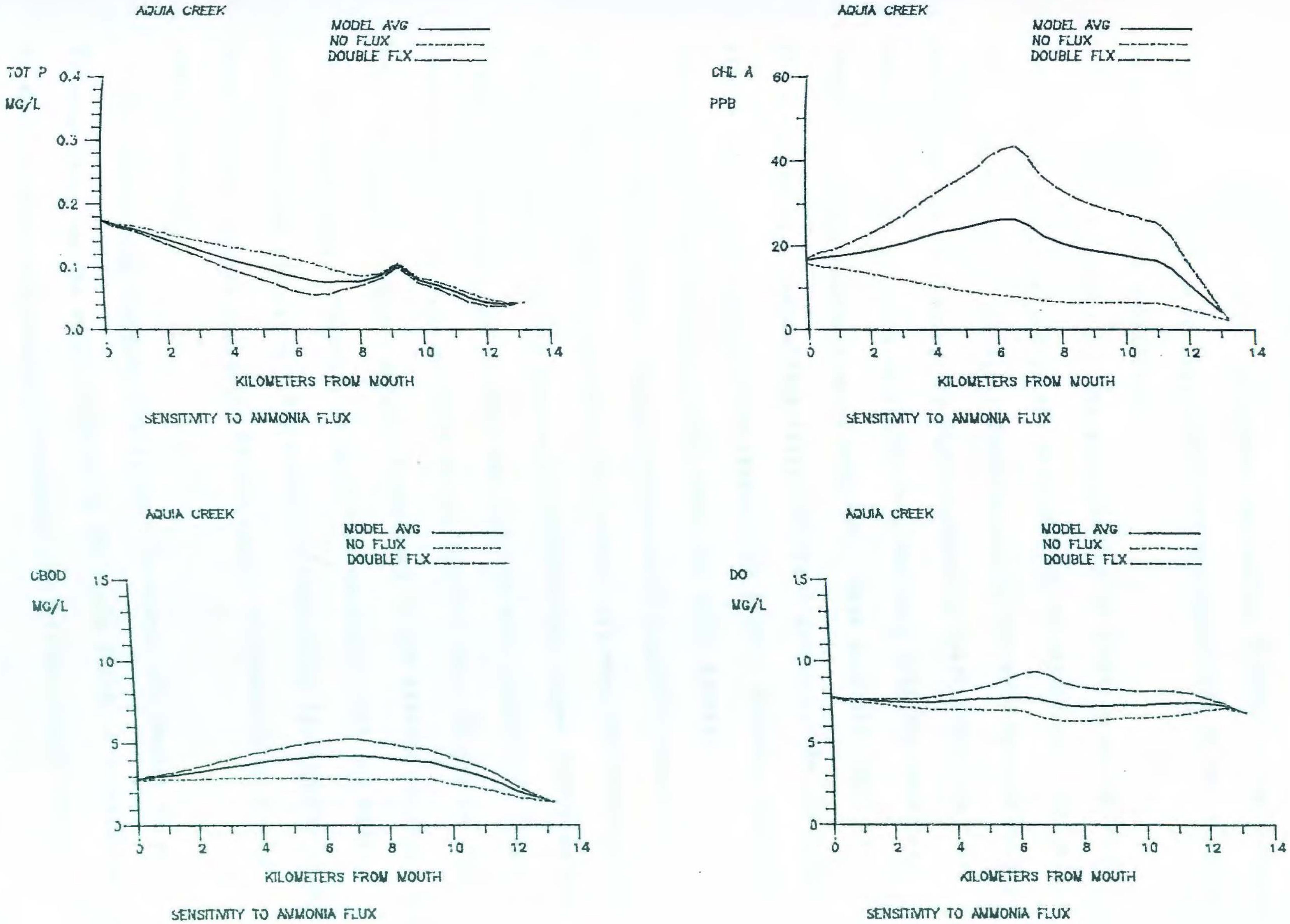


Figure 7-6. (Cont'd).

employed in model calibration. To test the system response, two sensitivity runs are made with ortho phosphorus flux being 0.01 and 0.02 $gm/m^2/day$, respectively, throughout the creek. Results are presented in Figure 7-7. It is seen that the additional phosphorus in the creek has no effect on algal population.

6) Light Extinction - The availability of light is as important to phytoplankton production as the availability of nutrients. The role of light limitation in the Aquia Creek system is examined by alternately increasing and decreasing the light-extinction coefficients by fifty percent. Results, shown in Figure 7-8, indicate that the sensitivity to decrease in light extinction is moderate. This suggests that, at present, the main controlling factor of algal growth in the Aquia Creek system is nutrient availability rather than light. However, further increase in light extinction will limit the algal growth.

7) Nonpoint Source - The contribution of nonpoint source is examined by a model sensitivity run in which all nonpoint loadings are eliminated except for the flow rate and dissolved oxygen concentration. Figure 7-9 presents the average and range of model prediction from sensitivity run as well as those of calibration run. It can be seen that the nonpoint source impact is confined to the extreme upstream end of the creek only. However, it should be mentioned that the model calibration run simulates a dry period of relatively low nonpoint source runoff. The results presented herein cannot be generalized to high runoff conditions.

8) Downstream Boundary Condition - To assess the impact of the Potomac River on the water quality in the Aquia Creek, a sensitivity run is made in which all downstream boundary conditions, except for

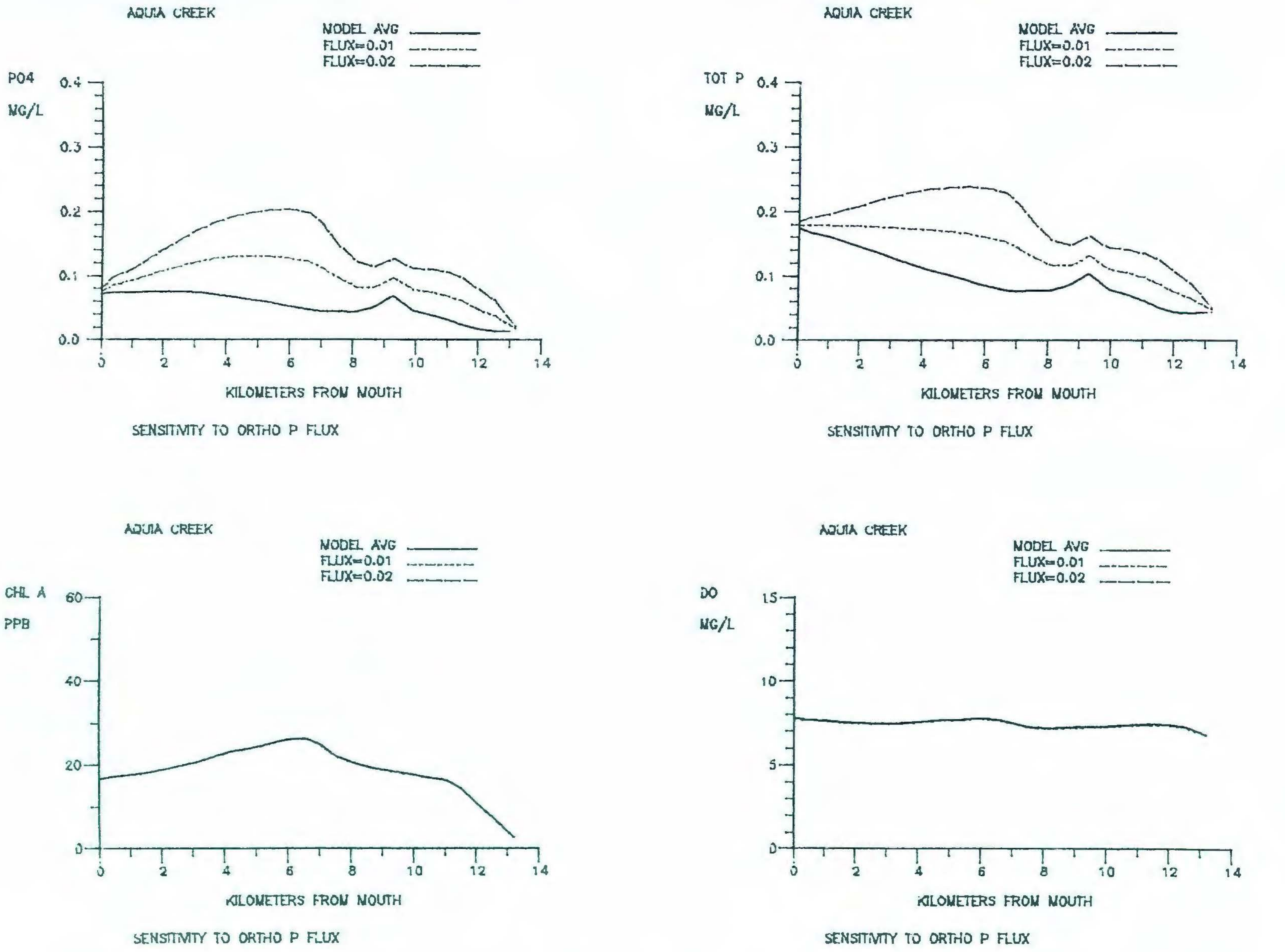


Figure 7-7. Sensitivity of the creek to benthic phosphorus flux.

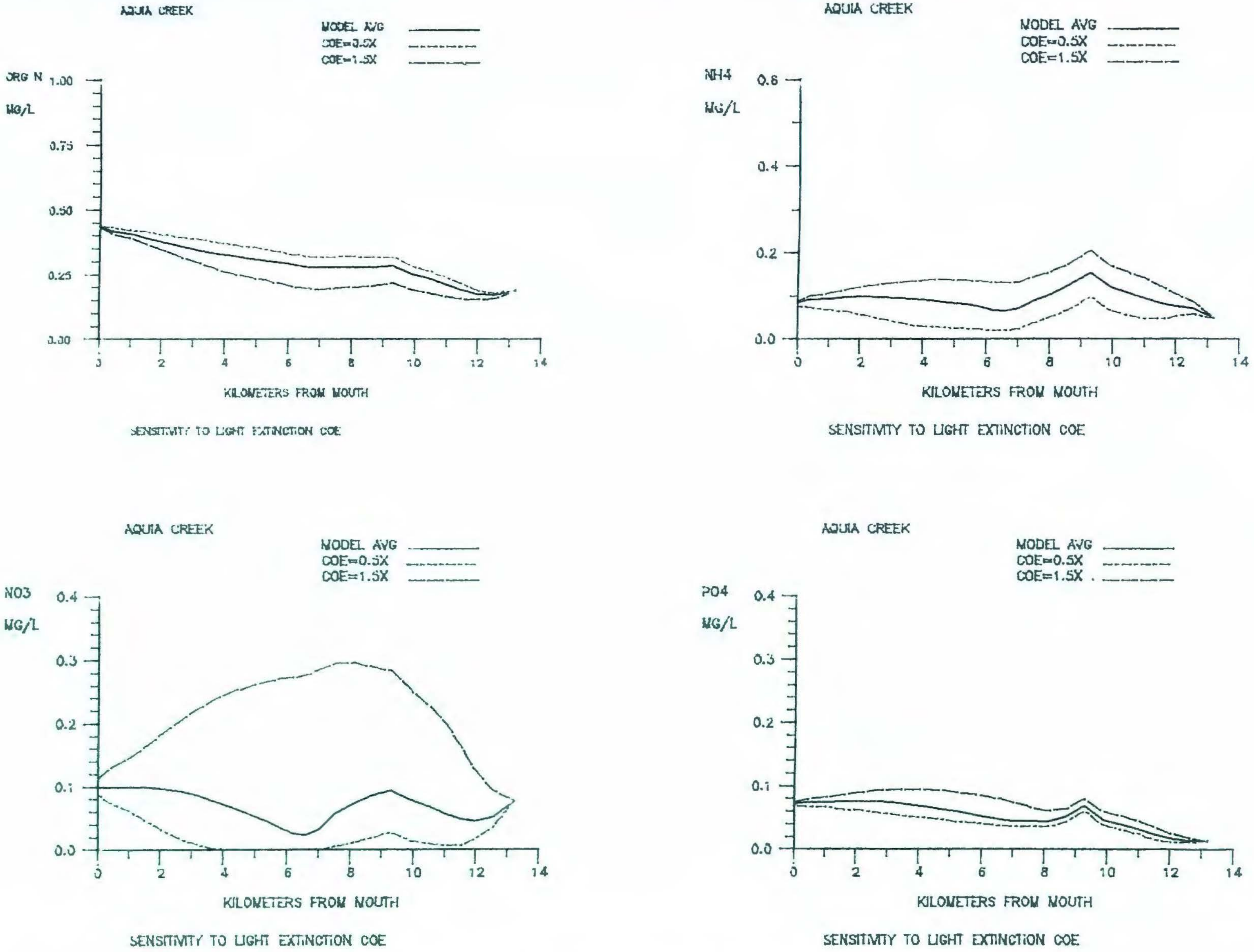
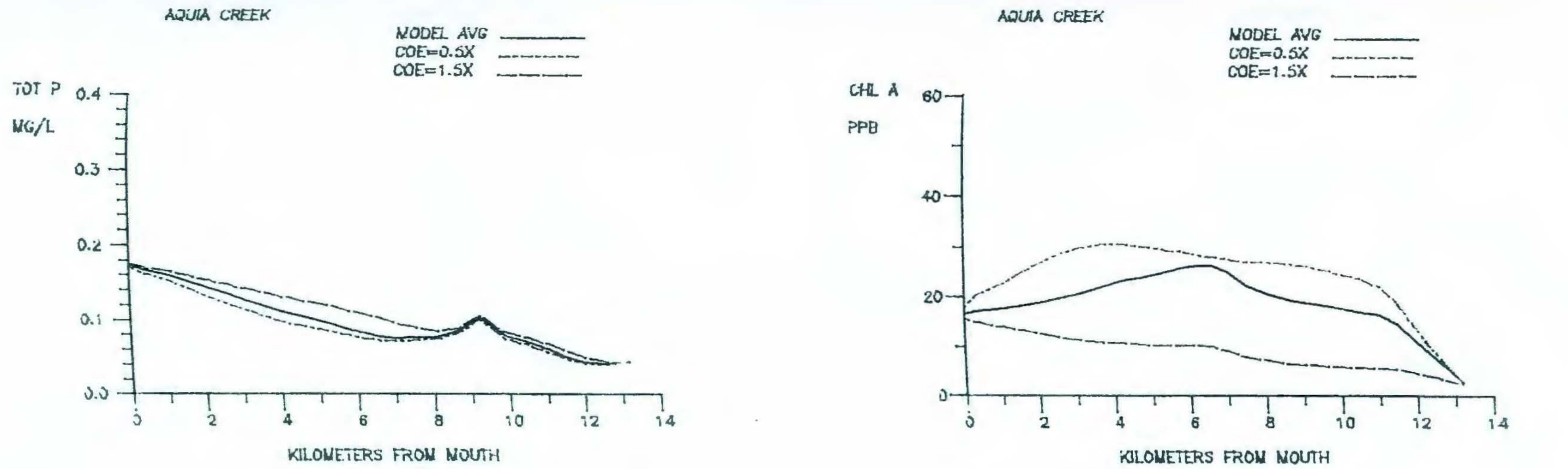
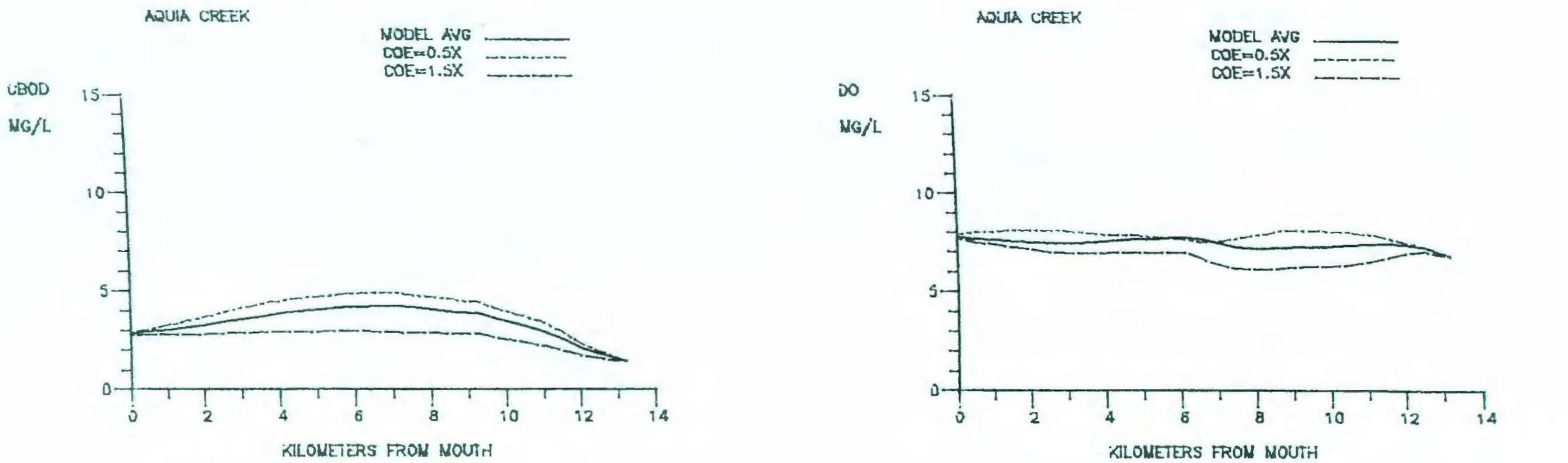


Figure 7-8. Sensitivity of the creek to light extinction.



SENSITIVITY TO LIGHT EXTINCTION COE

SENSITIVITY TO LIGHT EXTINCTION COE



SENSITIVITY TO LIGHT EXTINCTION COE

SENSITIVITY TO LIGHT EXTINCTION COE

Figure 7-8. (Cont'd).

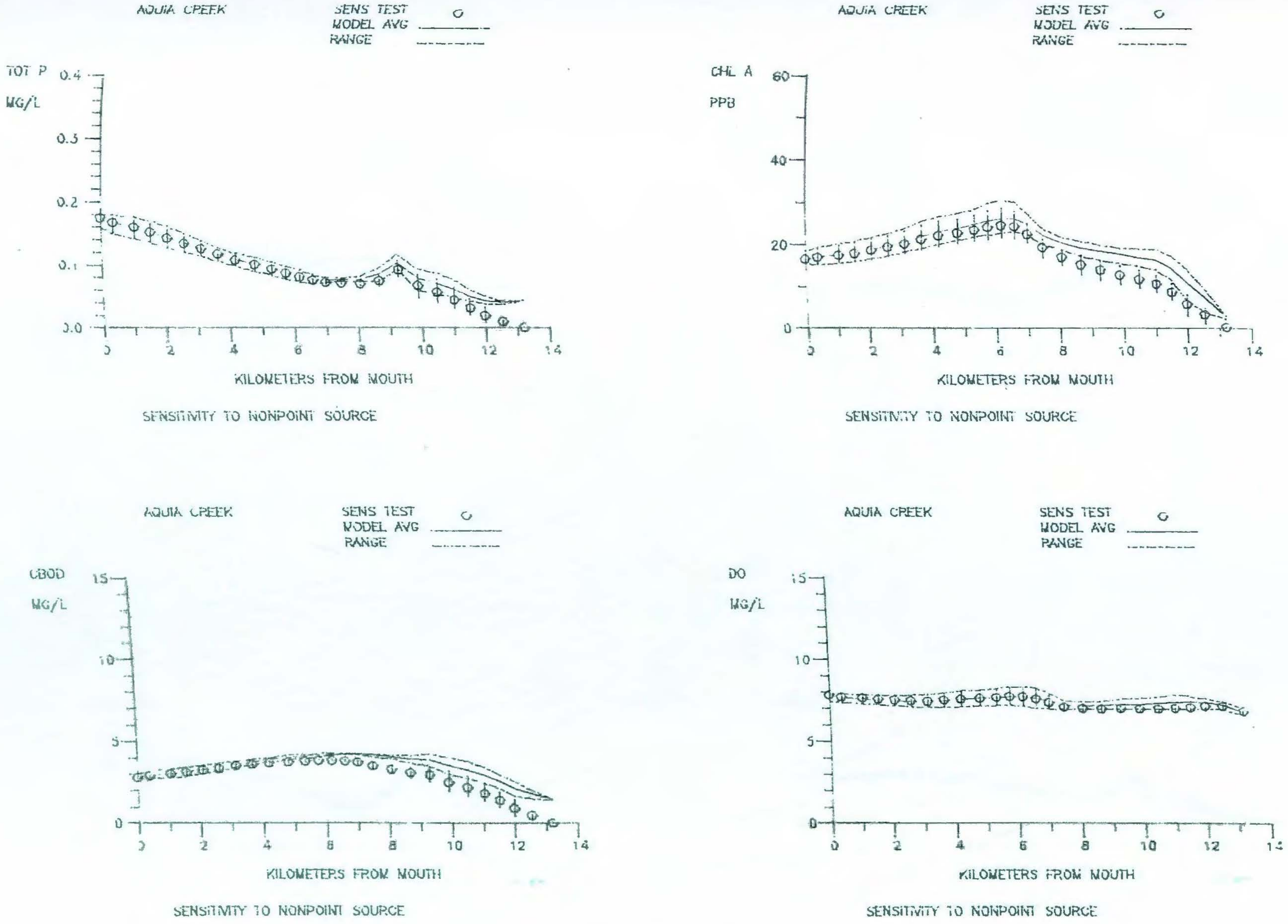


Figure 7-9. Sensitivity of the creek to nonpoint source.

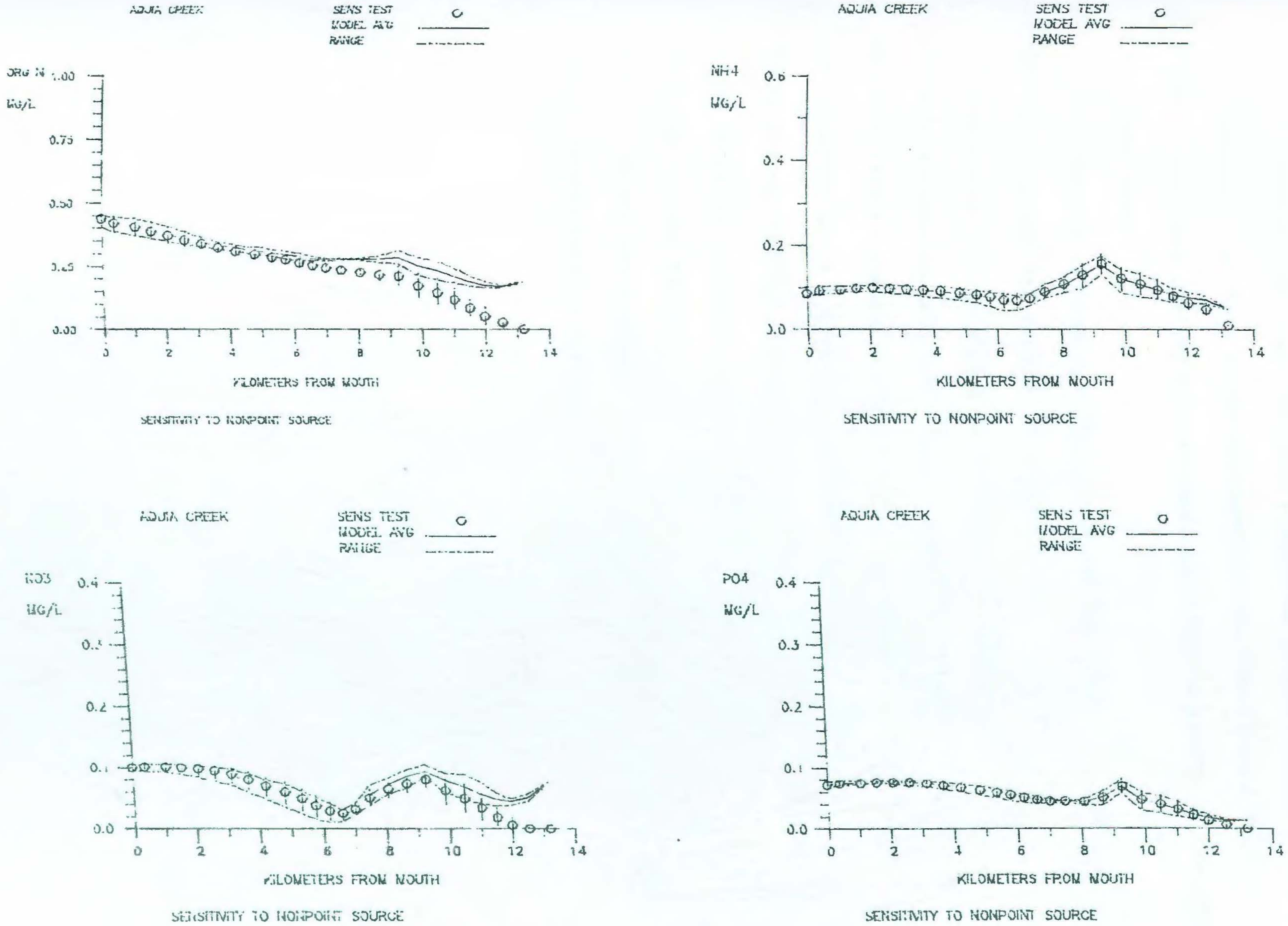
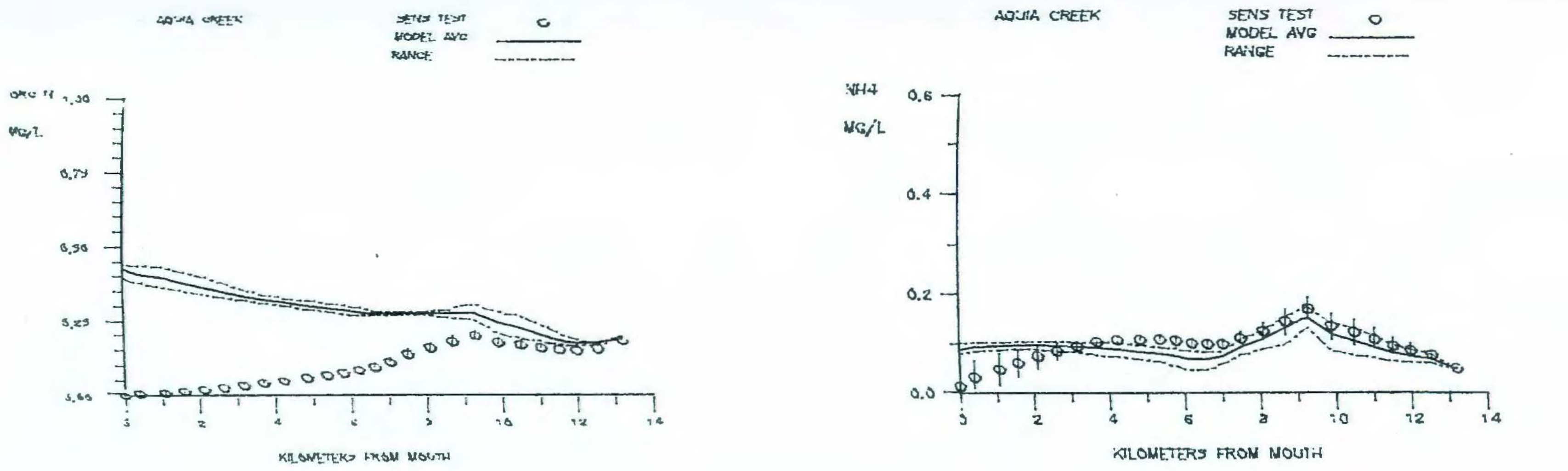


Figure 7-9. (Cont'd).

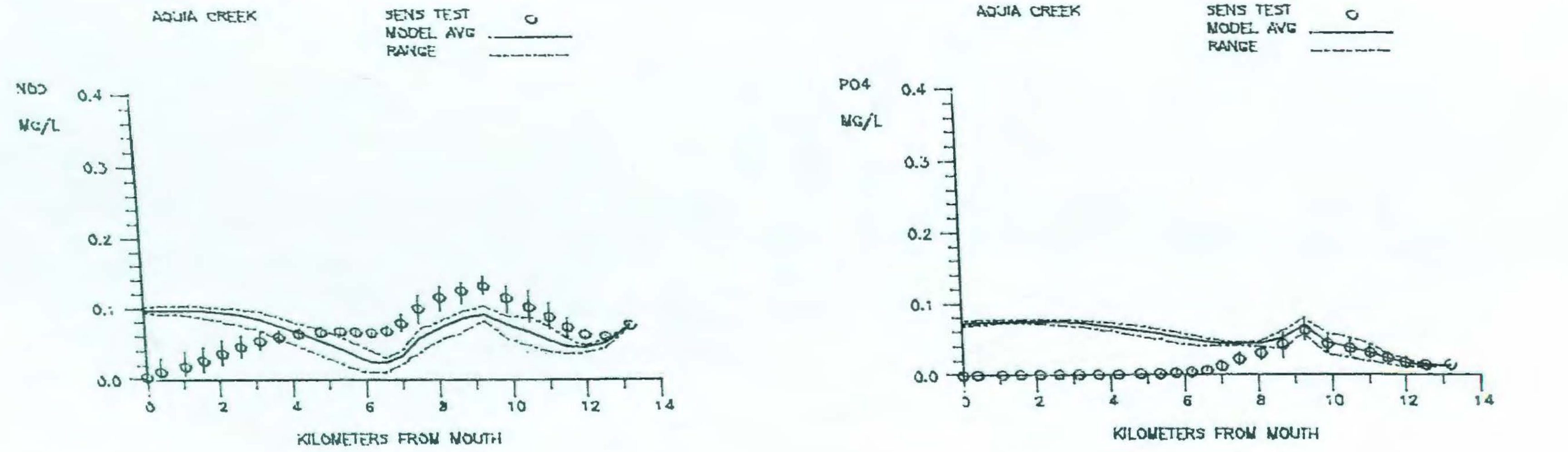
dissolved oxygen, are set to zero. Results are presented in Figure 7-10. The average and range of model prediction from the sensitivity run are compared with those of the calibration run. The Potomac River affects the water quality in most parts of the creek except for the very upstream reach.

9) Summary of Results - The results of the sensitivity analyses directed towards the factors which enhance and limit the algal population may be summarized as follows. During the August, 1981 calibration period, the Aquia Creek system was nitrogen limited. The benthic flux of ammonia nitrogen plays a significant role in supporting the observed algal population throughout the creek. The influence of point source loadings are mainly confined to the narrow section of the creek which is upstream of abrupt geometric change at km 7. The input from the Potomac River influences the water quality at most parts of the creek. During dry periods, the nonpoint source loadings have limited impact in the extreme upstream end of the creek.



SENSITIVITY TO DOWNSTREAM BOUNDARY

SENSITIVITY TO DOWNSTREAM BOUNDARY



SENSITIVITY TO DOWNSTREAM BOUNDARY

SENSITIVITY TO DOWNSTREAM BOUNDARY

Figure 7-10. Sensitivity of the creek to inputs from Potomac River.

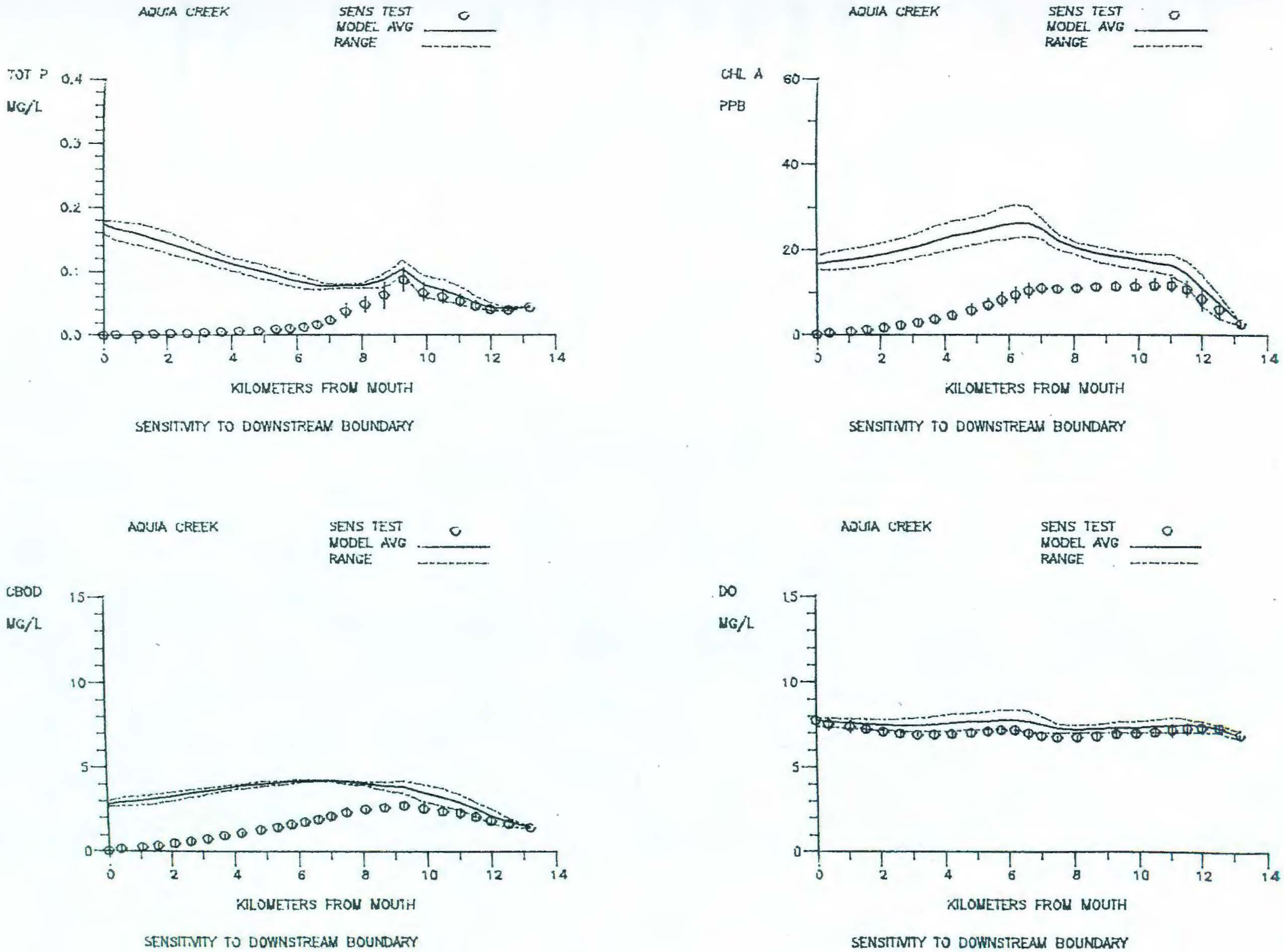


Figure 7-10. (Cont'd).

CHAPTER VIII. DISCUSSION

A mathematical water-quality model has been applied to the tidal portion of the Aquia Creek. The model consists of two submodels, the hydrodynamic and water quality submodels. Both are one-dimensional, time variable models, the former is based on the principles of conservation of volume, momentum and mass, the latter is based on the conservation of mass alone.

The hydrodynamic model provides real-time predictions of surface level, current, and transport of a conservative substance. Calibration analysis shows that the model provides near-perfect predictions of surface level within the creek (Figure 5-4). This is demonstrative of both the applicability of the model and of the unified response of the creek to tidal fluctuations at the mouth. The verification of current (Figure 5-3) is less ideal than tide but results are still more than sufficient for the purposes of this study. Discrepancies between predictions and observations are attributable to the collection and nature of the observations rather than to shortcomings of the model.

The ability of the model to predict mass transport and dispersion has been verified. The model has successfully simulated the nonsteady-state longitudinal distribution of dye (Figure 5-5).

The water-quality model provides one-dimensional, real-time predictions of eight water-quality parameters. The water-quality parameters are:

organic nitrogen
ammonia nitrogen
nitrite-nitrate nitrogen

organic phosphorus
ortho phosphorus
chlorophyll 'a'
carbonaceous biochemical oxygen demand
dissolved oxygen

The water-quality model has been calibrated and verified against two independent data sets and in different modes of operation. These are:

- Calibration of approximately steady-state longitudinal distribution of all parameters. August, 1981, intensive survey.

- Verification of long-term predictive ability through simulation of intertidally varying longitudinal distributions of all parameters. June-August, 1981, slackwater surveys.

- Verification of long-term predictive ability through simulation of time varying creek-wide average concentrations of all parameters. June-August, 1981, slackwater surveys.

The agreement between predictions and observations is more than satisfactory. In general, the predictive ability of the model is dependent upon the quality and quantity of the input data upon which the model run is based. Agreement between predictions and observations is dependent upon both the input data and the nature and number of observations. Thus, the results of the simulations of the intensive survey periods are more satisfactory than the results of the seasonal simulation.

The water-quality model results are commensurate with the data available to this study. It is unlikely that adopting a more sophisticated model would provide significantly improved predictive capability without the collection of additional and more comprehensive data. Even then, discrepancies between predictions and observations would still persist due to the random variability inherent in natural systems.

An additional cause of the discrepancies which exist between predictions and observations is the goal of consistency which motivated the calibration and verification procedures. The objective of these procedures was to find a single set of model parameters which would provide satisfactory predictions in all cases rather than to employ survey-specific parameters in an effort to obtain the best fit to the data. The goal of consistency was fulfilled in this study.

Both the field observations and model simulations indicate that the water quality conditions are rather uniform throughout the tidal portion of the Aquia Creek. None of the water quality parameters exhibit any significant longitudinal gradient. Nutrient concentrations in the creek are very low. Organic nitrogen concentration was never observed to exceed 1.0 mg/1. Only in rare occasions, were the ammonia and nitrite-nitrate nitrogens measured above laboratory detection levels of 0.1 mg/1 and 0.06 mg/1 respectively. More than 95% of total phosphorus measurements are 0.1 mg/1, the laboratory detection limit. The ortho phosphorus concentrations are on the order of 0.05 mg/1. Ultimate carbonaceous biochemical oxygen demand is more variable, it ranges from zero to more than 10 mg/1, and shows no persistent spatial trend. This may reflect both the natural variability and the imprecise analyses which determine this parameter. However, a clear temporal trend may be noted (Figure 6-5) as CBOD concentration increases in response to stormwater runoff.

The daily average chlorophyll concentrations are about 25 µg/1. Superimposed upon the daily average is the diurnal variation. During the 1981 intensive survey, the diurnal range of chlorophyll was roughly 20 µg/1. The maximum concentration observed never exceeded 40 µg/1. Both the field data and model simulations suggest that the algal growth in the system is nitrogen limited. Both inorganic nitrogen inputs from the STP discharge and from the Potomac River play an important role in supporting the algal population in the creek. The influence of the STP discharge is mainly confined to the narrow section of the creek at the upstream end (Figure 7-5). The influence of the Potomac River dominates the wide embayment at the downstream end (Figure 7-10). The benthic flux of ammonia nitrogen also plays a significant role in supporting the algal population. Without that benthic flux of ammonia nitrogen, the chlorophyll concentration would be reduced by about 50% (Figure 7-6). Because the system is nitrogen limited, additional phosphorus has little effect on the algal population (Figures 7-4 and 7-7), assuming no change of algal species would occur. On the other hand, eliminating the phosphorus discharged from the point source could shift portions of the system from nitrogen limited to phosphorus limited, and suppresses the algal population in the upstream section of the creek (Figures 7-4 and 7-5).

Dissolved oxygen concentrations in the creek are generally on the order of 7-8 mg/l. Occasional low DO's of 5 mg/l or less have been observed. They were mostly observed shortly after stormwater runoff events. The sporadic high ammonia discharges from the STP also might contribute to the occasional low DO, if the nitrogen was not taken up by the phytoplankton immediately.

The Aquia STP is the only point source of wastewater discharging into the creek. Its outfall is located in Austin Run, a small tributary of the Aquia. During the 1981 survey period (May to September), the STP discharged an average flow of 0.86 mgd (0.038 m^3/sec) with relatively constant phosphorus concentration, about 5 mg/l. Ammonia nitrogen is the primary form of nitrogen in the effluent. Its concentration varied over a wide range, from 0.5 to 12.5 mg/l. Evidence indicates that a significant fraction of the ortho phosphorus is adsorbed to sediment particles shortly after being discharged. The STP discharge had substantially lower nutrient concentrations during the surveys of July and August, 1982, however, no noticeable water quality difference from that of 1981 was observed. The nonpoint source runoff probably could have supplied enough nutrients to support the same level of algal population as 1981.

The influence of nonpoint source runoff is generally confined to the upstream narrow portion of the creek (Figure 7-9). During dry periods, the nonpoint source nitrogen loading is comparable to that of point source, while the phosphorus loading is negligible. During stormwater runoff events, the nonpoint nitrogen loading dominates over that of the point source and the phosphorus loading becomes comparable. Only in the extreme high runoff occasions will the nonpoint source completely dominate over point source, and its impact is felt all the way down to the wide embayment portion of the creek.

REFERENCES

Banks, R. B. and F. F. Herrera, 1977. "Effect of Wind and Rain on Surface Reaeration". J. of the Envr. Eng. Div., ASCE. Vol. 103, No. EE3, pp. 489-504.

Brezonik, P. L., 1977. "Denitrification in Natural Waters". Prog. Wat. Tech., Vol. 8, Pergamon Press, pp. 373-392.

Carritt, D. E. and E. J. Green, 1967. "New Tables for Oxygen Saturation in Seawater", J. of Mar. Res., Vol. 25, #2.

Cerco, C. F. and A. Y. Kuo, 1983. "Water Quality in a Virginia Potomac Embayment: Hunting Creek - Cameron Run". SRAMSOE No. 244. Virginia Institute of Marine Science, Gloucester Point, Va.

DiToro, D. M., D. J. O"Connor and R. V. Thomann, 1971. "A Dynamic Model of the Phytoplankton Population in the Sacramento-San Joaquin Delta". Adventures in Chemistry Series No. 106, American Chemical Society, pp. 131-180.

Edwards, R. W. and H. L. J. Rolley, 1965. "Oxygen Consumption of River Muds". J. Ecol. 53, 1-19.

Harleman, D. R. F., 1971. "One-Dimensional Models". in **Estuarine Modeling**, an Assessment, Tracor, Inc.

Lake, C. A. and W. G. MacIntyre, 1977. "Phosphate and Tripolyphosphate adsorption by Clay Minerals and Estuarine Sediment". Va. Water Resources Research Center, Blacksburg, Bulletin 109.

Mayer, L. M. and S. P. Gloss, 1980. "Buffering of Silica and Phosphate in a Turbid River". Limmology and Oceanography 25(1), pp. 12-22.

O'Connor, D. J. and W. E. Dobbins, 1958. "Mechanism of Reaeration in Natural Streams", Trans. Am. Soc. of Civil Eng., Vol. 123.

Parfitt, R. L., R. J. Atkinson and R. Smart, 1975. "The Mechanism of Phosphate Fixation by Iron Oxides". Soil Science Society of Am. Jour., Vol. 39, pp. 837-841.

Riley, G. A., 1956. "Oceanography of Long Island Sound 1952-1954. II. Physical Oceanography", Bull. Bingham Oceanog. Coll. No. 15, pp. 15-46.

Sverdrup, H. W., M. W. Johnson, and R. H. Fleming, 1970. **The Oceans**, Prentice-Hall, Inc., Englewood Cliffs, N. J., p. 82.

Thomann, R. V. and J. J. Fitzpatrick, 1982. "Calibration and Verification of a Mathematical Model of the Eutrophication of the Potomac Estuary". HydroQual, Inc., Mahwah, New Jersey.

van Kessel, J. F., 1977. "Removal of Nitrate from Effluent Following Discharge on Surface Water". Water Research, Vol. 11.

Veith, J. A. and S. Sposito, 1977. "Reactions of Aluminosilicates, Aluminum Hydrous Oxide and Aluminum Oxide with O-Phosphate". Soil Science Society of Am. Jour., Vol. 41.

Williams, S. A. and A. Y. Kuo, 1984. "Water Quality Studies of Little Hunting Creek". SRAMSOE No. 268. Virginia Institute of Marine Science, Gloucester Point, Va.

Appendix A. Slackwater and Intensive Survey Data

AQUIA CREEK SLACK WATER QUALITY DATA

D M Y= 26 5 81 , TIDE = H

TIME (HR)	STN	SEC CHI (M)	BOT TOM (M)	SAM PLE DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
11.0	00001	0.3	3.	1.5	21.80	9.00	17.70	0.60	0.01	0.01	0.81	0.10	0.04	2.18	9.70		9.50
11.1	00002	0.3	2.	1.0	22.00	10.00	32.80	0.80	0.10	0.01	0.28	0.10	0.04	3.63	10.60		9.80
*11.5	00003	0.4	1.	0.5	25.20	22.00	16.40	9.00	2.50	1.30	0.95	5.90	5.50	5.00	10.60		9.80
11.7	00004	0.4	2.	1.0	25.10	7.00	14.80	0.80	0.10	0.01	0.08	0.10	0.03	4.00	8.40		8.80
12.0	00005	0.0	2.	1.0	26.20	14.00	12.20	0.80	0.10	0.01	0.08	0.10	0.03	5.00	7.80		7.30
12.5	00006	0.0	2.	1.0	24.90	11.00		0.70	0.10	0.01	0.06	0.10	0.05	5.00	7.90		7.60
12.8	00007	0.5	2.	1.0	26.10	14.00		0.50	0.10	0.01	0.06	0.10	0.02	4.00	11.00		8.20
12.1	00008	0.0	0.	0.1	23.50	7.00	1.40	0.40	0.10	0.01	0.10	0.10	0.02	1.00	7.20		7.00
11.3	00009	0.0	0.	0.1	20.50	11.00		0.80	0.10	0.01	0.06	0.10	0.03	4.83	6.10		7.00
11.6	00010	0.0	0.	0.1	22.00	6.00	3.50	0.10	0.10	0.01	0.06	0.10	0.01	1.00	7.60		7.00

*sample mislabeling is suspected.

AQUIA CREEK SLACK WATER QUALITY DATA

D M Y= 11 6 81 , TIDE = L

TIME (HR)	STN	SEC CHI (M)	BOT TOM (M)	SAM PLE DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
8.0	00001	0.3	3.	1.5	25.00	9.00	19.20	0.70	0.10	0.01	0.07	0.10	0.05	1.00	6.20		7.60
8.3	00002	0.3	2.	1.0	25.10	9.00	18.60	0.60	0.10	0.01	0.05	0.10	0.04	2.00	6.70		7.70
8.5	00003	0.4	1.	0.5	26.00	11.00	20.70	0.80	0.10	0.01	0.05	0.10	0.04	2.00	5.20		7.50
9.0	00004	0.3	2.	1.0	25.10	11.00	20.50	0.70	0.10	0.01	0.05	0.10	0.04	1.00	6.90		7.10
9.1	00005	0.3	2.	1.0	25.00	9.00	22.90	0.90	0.30	0.02	0.05	0.10	0.04	2.00	5.20		6.60
9.4	00006	0.3	2.	1.0	25.40	8.00	21.20	0.90	0.30	0.02	0.06	0.10	0.04	1.00	5.10		6.50
9.6	00007	0.5	2.	1.0	26.10	8.00	17.00	1.00	0.20	0.01	0.07	0.10	0.02	1.13	2.50		6.40
10.0	00008	0.0	0.	0.1	23.00	6.00	1.60	0.50	0.20	0.01	0.09	0.10	0.03	0.50	7.10		7.10
9.5	00009	0.0	0.	0.1	21.00	10.00	1.50	16.50	12.50	0.12	0.21	4.80	4.80	2.75	7.30		8.80
8.0	00010	0.0	0.	0.1	19.50	5.00	0.60	0.30	0.10			0.10	0.01	0.58	8.40		7.30

AQUIA CREEK SLACK WATER QUALITY DATA

D M Y= 23 6 81 , TIDE =

TIME (HR)	STN	SEC CHI (M)	BOT TOM (M)	SAM PLE DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
4.9	00001	0.0	3.	1.5	26.30	11.00		1.00	0.10	0.01	0.05	0.10	0.05	2.10	8.30		8.50
5.2	00002	0.0	2.	1.0	26.00	15.00		1.10		0.01	0.05	0.20	0.06	2.73	7.50		7.90
5.5	00003	0.2	1.	0.5	25.90	14.00		1.10	0.10	0.01	0.05	0.10	0.06	3.15	5.80		7.10
5.8	00004	0.2	2.	1.0	26.50	13.00	36.00	1.10	0.10	0.02	0.05	0.10	0.06	2.50	5.10		7.00
6.0	00005	0.2	2.	1.0	26.80	12.00		0.80	0.20	0.02	0.04	0.10	0.05	2.00	4.20		6.60
6.3	00006	0.2	2.	1.0	26.80	11.00		0.70	0.10	0.01	0.05	0.10	0.04	2.00	4.40		6.60
6.5	00007	0.2	2.	1.0	26.90	10.00		0.80	0.20	0.01	0.05	0.10	0.03	1.00	5.20		6.90
4.9	00008	0.0	0.	0.1	25.50	9.00		0.50	0.10	0.01	0.08	0.10	0.04	0.83	6.30		7.50
6.0	00009	0.0	0.	0.1	22.50	14.00		2.30	1.00	0.02	1.10	4.40	4.20	1.00	6.90		7.50
4.7	00010	0.0	0.	0.1	20.00	7.00		0.30	0.10	0.01	0.10	0.10	0.03	1.00	8.00		7.20

AQUIA CREEK SLACK WATER QUALITY DATA

D M Y= 7 7 81 , TIDE = L

TIME (HR)	STN	SEC CHI (M)	BOT TOM (M)	SAM PLE DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
5.5	00001	0.2	3.	1.0	26.00	13.00		0.60	0.10			0.10	0.05	1.00	7.40		7.90
				1.5	26.00										7.40		
5.9	00002	0.3	2.	1.0	26.00	17.00	19.66	0.80	0.10	0.01	0.05	0.10	0.04	2.00	7.00		7.20
				1.5	26.00										6.90		
6.4	00003	0.2	2.	1.0	26.00	13.00	17.28	0.60	0.10	0.01	0.05	0.10	0.03	2.00	4.00		7.00
				1.5	26.00										3.80		
6.5	00004	0.2	1.	0.5	26.00	15.00	15.98	0.60	0.10	0.01	0.05	0.10	0.03	2.00	5.00		6.80
7.0	00005	0.2	2.	1.0	31.00	13.00		0.50	0.10	0.01	0.05	0.10	0.03	2.00	5.40		6.70
7.2	00006	0.2	2.	1.0	31.00	10.00		0.70		0.01	0.05	0.10	0.04	1.80	5.30		6.30
7.7	00007	0.4	3.	1.5	25.50	11.00	10.15	0.50	0.10	0.01	0.05	0.10	0.01	1.55	5.00		6.80
6.7	00008	0.0	0.	0.1	25.50	8.00	1.77	0.40	0.10	0.01	0.05	0.10	0.01	0.73	7.50		6.50
7.2	00009	0.0	0.	0.1	24.00	15.00		5.40	4.00	0.12	0.90	5.10	5.00	2.70	7.20		1.90
6.0	00010	0.0	0.	0.1	20.00	5.00		0.20	0.10	0.01	0.05	0.10	0.01	0.50	7.60		6.50

AQUIA CREEK SLACK WATER QUALITY DATA

D M Y= 23 7 81 , TIDE = H

TIME (HR)	STN	SEC CHI (M)	BOT TOM (M)	SAM PLE DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
10.1	00001	0.1	3.	1.5	27.00	12.00	29.16	1.00	0.10	0.01	0.05	0.10	0.05	3.08	9.00		8.50
10.4	00002	0.1	2.	1.0	27.00	11.00	28.08	0.90	0.10	0.01	0.05	0.20	0.03	3.18	10.00		8.50
10.7	00003	0.2	1.	0.5	27.00	11.00	29.81	0.80	0.10	0.01	0.05	0.10	0.05	3.23	7.20		7.70
11.0	00004	0.2	2.	1.0	27.00	15.00	28.08	0.90	0.10	0.01	0.05	0.10	0.07	4.53	7.30		7.70
11.1	00005	0.1	2.	1.0	27.00	17.00	24.84	0.80	0.10	0.01	0.05	0.10	0.06	3.95	7.30		7.80
11.5	00006	0.1	2.	1.0	28.00	17.00	19.44	0.70	0.10	0.01	0.05	0.10	0.04	3.00	6.60		7.30
11.7	00007	0.1	2.	1.0	29.00	13.00	13.61	0.60	0.10	0.01	0.05	0.10	0.03	3.00	7.20		7.20
11.5	00008	0.0	0.	0.1	25.00	7.00		0.30	0.10	0.01	0.12	0.10	0.01	1.00	8.80		6.70
10.2	00009	0.0	0.	0.1	23.50	14.00	1.04	1.40	0.60	0.01	0.70	5.10	5.00		7.00		6.90
11.0	00010	0.0	0.	0.1	23.50	7.00	2.35	0.20	0.10	0.01	0.05	0.10	0.01	1.00	8.80		6.60

AQUIA CREEK SLACK WATER QUALITY DATA

D M Y= 5 8 81 , TIDE = H

TIME (HR)	STN	SEC CHI (M)	BOT TOM (M)	SAM PLE DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
10.3	00001	0.3	3.	1.5	28.60	9.00	19.01	0.60	0.10	0.01	0.15	0.10	0.07	1.00	7.80		7.90
10.5	00002	0.3	2.	1.0	29.00	11.00	22.68	0.60	0.10	0.01	0.05	0.10	0.06	2.00	8.70		8.00
10.9	00003	0.2	1.	0.5	29.00	15.00	14.26	0.80	0.10	0.01	0.05	0.10	0.05	3.00	8.30		8.10
11.1	00004	0.2	2.	1.0	29.10	11.00	27.43	0.60	0.10	0.01	0.05	0.10	0.03	3.00	7.60		6.20
11.3	00005	0.2	2.	1.0	28.00	12.00	22.25	0.60	0.10	0.01	0.05	0.10	0.04	2.00	5.40		6.20
11.6	00006	0.3	2.	1.0	27.80	9.00	14.04	0.50	0.10	0.01	0.05	0.10	0.03	0.82	5.70		6.20
12.0	00007	0.3	2.	1.0	27.80	9.00	17.93	0.04	0.10	0.01	0.05	0.10	0.01	1.25	6.40		6.50
12.8	00008	0.0	0.	0.1	27.70	8.00	0.48	0.40	0.10	0.01	0.05	0.10	0.01	0.93	6.90		6.60
11.0	00009	0.0	0.	0.1	26.50	12.00		1.30	0.50	0.01	2.20	4.20	4.00	0.28	6.60		6.90
10.6	00010	0.0	0.	0.1	23.00	6.00	0.69	0.10	0.10	0.01	0.05	0.10	0.02	0.45	8.20		6.30

AQUIA CREEK SLACK WATER QUALITY DATA

D M Y= 23 8 81 , TIDE =

TIME (HR)	STN	SEC CHI (M)	BOT TOM (M)	SAM PLE DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
12.3	00009	0.0	0.	0.1	21.00										6.50		7.70
12.5	00008	0.0	0.	0.1	21.00										8.60		6.60
11.7	00010	0.0	0.	0.1	19.10										8.80		6.70

AQUIA CREEK SLACK WATER QUALITY DATA

D M Y= 26 8 81 , TIDE =

TIME (HR)	STN	SEC CHI (M)	BOT TOM (M)	SAM PLE DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
4.0	00001	0.0	3.	0.1	23.80										7.40	0.03	
4.2	00002	0.0	2.	0.1	23.80										7.70	0.03	
4.4	00003	0.0	1.	0.1	24.00										8.50	0.04	
4.7	00004	0.0	2.	0.1	24.10										7.60	6.50	
5.0	00005	0.0	2.	0.1	24.10										6.80	1.99	
5.2	00006	0.0	2.	0.1	24.70										6.50	1.28	
5.5	00007	0.0	2.	0.1	24.00										7.00	0.02	

AQUIA CREEK SLACK WATER QUALITY DATA

D M Y= 27 8 81 , TIDE =

TIME (HR)	STN	SEC CHI (M)	BOT TOM (M)	SAM PLE DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
3.8	00001	0.0	3.	0.1	23.80										7.50	0.03	
4.0	00002	0.0	2.	0.1	24.10										7.40	0.03	
4.3	00003	0.0	1.	0.1	24.30										8.40	0.08	
4.5	00004	0.0	2.	0.1	24.50										7.70	0.43	
4.7	00005	0.0	2.	0.1	24.60										7.10	0.04	
5.0	00006	0.0	2.	0.1	24.70										6.40	1.80 *	
5.4	00007	0.0	2.	0.1	24.10										7.00	1.85 *	

*sample mislabeling is suspected.

AQUIA CREEK SLACK WATER QUALITY DATA

D M Y= 28 8 81 , TIDE =

TIME (HR)	STN	SEC CHI (M)	BOT TOM (M)	SAM PLE DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
4.8	00001	0.0	3.	0.1	23.90										6.50	0.03	
5.0	00002	0.0	2.	0.1	24.00										6.80	0.06	
6.1	00003	0.0	1.	0.1	24.40										7.30	0.16	
5.3	00004	0.0	2.	0.1	25.10										7.20		
5.5	00005	0.0	2.	0.1	25.30										6.30	1.35	
5.7	00006	0.0	2.	0.1	25.10										5.80	1.26	
6.0	00007	0.0	2.	0.1	24.80										6.60	0.21	

AQUIA CREEK SLACK WATER QUALITY DATA

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                                 D M Y= 21  9 81 , TIDE = H
 TIME   STN   SEC  BOT  SAM  TEMP   TOC  CHLOR  TKN  NH3-N  NO2   NO3  TOT-P INO-P CBOD5  DO    DYE    PH
 (HR)         CHI  TOM  PLE                PHYLL              N     N
              (M)  (M) DEPTH (C)  (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

 11.1 00001 0.5   3.   1.0 21.50  8.00        0.50  0.10  0.03  0.22  0.10  0.07  2.03  8.70        8.00
                       1.5 20.20                                                        8.30
 11.4 00002 0.5   2.   1.0 21.30 11.00        0.70  0.10  0.01  0.05  0.10  0.06  4.40 11.20        8.20
                       1.5 19.70                                                       10.10
 11.7 00003 0.2   2.   1.0 21.80 12.00        0.70  0.10  0.01  0.05  0.10  0.04  5.10 11.80        8.50
                       1.5 19.30                                                        9.20
 12.0 00004 0.3   2.   1.0 21.60 12.00        0.70  0.10  0.01  0.05  0.10  0.04  4.25 11.90        8.10
                       1.5 20.20                                                       10.00
 12.2 00005 0.3   3.   1.5 21.00 11.00        0.70  0.10  0.01  0.05  0.10  0.03  4.20 10.80        7.70
 12.5 00006 0.4   2.   1.0 20.00 10.00        0.70  0.30  0.03  0.06  0.10  0.05  3.00  7.80        7.00
 12.0 00009 0.0   0.   0.1 19.50 11.00       14.40  9.50  0.08  0.13  5.60  5.50  1.33  7.50        2.40
 12.2 00010 0.0   0.   0.1 16.00  5.00        0.10  0.10  0.01  0.05  0.10  0.01  1.00 10.40        6.70
 12.7 00007 0.6   2.   1.0 20.00 10.00        0.50  0.10  0.01  0.05  0.10  0.03  3.00  6.80        6.80
 13.0 00008 0.0   0.   0.1 19.50  9.00        0.30  0.10  0.01  0.05  0.10  0.01  1.00 10.30        8.70
.01   1.00 10.30         8.70
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AQUIA CREEK SLACK WATER DATA

JUL 26, 82, CRUISE OSAQ1, TIDE IS H.

TIME (HR)	STN	SEC CHI (M)	BOT TOM (M)	SAM PLE DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
9.9	00001	0.5	3.	1.5	29.50	5.00	12.87	0.50	0.10	0.00	0.59	0.20	0.11	1.10	7.50		7.10
10.2	00002	0.3	2.	1.0	29.00	8.00	33.75	0.60	0.10	0.01	0.05	0.10	0.03	2.00	10.20		9.00
10.5	00003	0.3	2.	1.0	30.00	10.00	23.20	0.80	0.10	0.01	0.05	0.10	0.03	2.00	9.40		9.30
10.8	00004	0.0	2.	1.0	30.50	9.00	34.17	0.70	0.10	0.01	0.05	0.10	0.03	4.00	9.40		9.00
11.1	00005	0.1	2.	1.0	30.00	11.00	33.32	0.70	0.10	0.01	0.05	0.20	0.02	3.00	9.30		8.30
11.5	00006	0.1	3.	1.5	30.00	12.00	33.75	0.70	0.10	0.01	0.13	0.10	0.03	4.00	9.20		7.70
11.7	00007	0.5	3.	1.5	30.00	10.00	26.15	0.60	0.10	0.01	0.24	0.10	0.02	3.00	9.20		7.50
10.4	00008	0.0	0.	0.5	25.30	4.00	2.66	0.30	0.10	0.01	0.05	0.20	0.02	0.40	8.10		7.00
8.8	00009	0.0	0.	0.5	23.00	4.00		0.50	0.10	0.01		0.80	0.70	1.18	8.40		4.00
9.1	00010	0.0	0.	0.5	21.50	1.00	0.91	0.20	0.10	0.01	0.07	0.20	0.02	1.00	8.40		6.80

AQUIA CREEK SLACK WATER DATA

AUG 12, 82, CRUISE OSAQ2, TIDE IS H.

TIME (HR)	STN	SEC CHI (M)	BOT TOM (M)	SAM PLE DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
11.0	00001	0.5	3.	1.0	26.00										9.40		
				1.5		13.00	25.31	0.70	0.10	0.01	0.30	0.10	0.05	1.95			8.50
				2.0	26.00										8.80		
11.3	00002	0.5	2.	0.5	26.50										9.90		
				1.0		9.00	31.00	0.70	0.10	0.01	0.09	0.10	0.03	2.00			8.30
				1.5	26.50										9.80		
11.5	00003	0.5	2.	0.5	26.00										9.60		
				1.5	26.00	11.00	26.57	0.70	0.10	0.01	0.05	0.10	0.03	3.00	9.40		8.90
11.7	00004	0.5	2.	1.0	26.50	12.00	27.63	0.70	0.01	0.01	0.05	0.10	0.02	6.00	9.20		8.70
11.9	00005	0.4	2.	1.0	26.00	12.00	33.75	0.70	0.10	0.01	0.05	0.10	0.03	3.00	10.20		8.70
12.0	00006	0.4	2.	1.0	26.50	12.00	34.80	0.60	0.10	0.01	0.23	0.10	0.02	3.00	8.40		7.60
12.2	00007	0.5	2.	1.0	26.50	11.00	26.79	0.60	0.10	0.01	0.05	0.10	0.01	2.90	6.40		7.20
13.2	00008	0.0	0.	0.5	25.50	7.00	4.01	0.30	0.10	0.01	0.05	0.10	0.01	0.93	8.40		7.10
10.4	00009	0.0	0.	0.5	23.50	5.00		0.70	0.10	0.01		0.20	0.16	0.25	7.80		3.90
11.1	00010	0.0	0.	0.1	21.00	4.00	0.80	0.10	0.10	0.01	0.07	0.10	0.01	1.00	8.70		7.10

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 24 8 81 , STN = 00001, BOTTOM DEPTH = 3.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEPTH (M)	TEMP (C)	TOC (MG/L)	CHLORPHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
13.0	0.4	2.	24.00	8.00	10.64	0.50	0.10	0.07	0.12	0.20	0.09	1.13	7.40	0.03	
14.1	0.3	2.	23.80		13.97								8.50		
15.1	0.3	2.	23.60	13.00	17.74	0.60	0.10	0.02	0.05	0.20	0.05	2.00	7.20		
16.1	0.3	2.	25.00		20.62								11.80		
17.1	0.2	2.	24.50	12.00	15.96	0.70	0.10	0.01	0.05	0.20	0.06	4.00	8.00	0.30	
18.2	0.2	2.	24.50		21.73								8.10		
19.1	0.2	2.	24.50	45.00	19.95	0.70	0.10	0.01	0.05	0.20	0.05	2.75	7.50	0.30	
20.3	0.0	2.	24.70		11.08								7.20		
21.0	0.0	2.	24.30	10.00	15.30	0.70	0.10	0.01	0.05	0.20	0.06	2.00	8.10		
22.1	0.0	2.	23.80		8.42								7.50	0.03	
23.1	0.0	2.	23.50	9.00	10.42	0.50	0.10	0.07	0.11	0.20	0.10	1.00	7.00		

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 25 8 81 , STN = 00001, BOTTOM DEPTH = 3.00 M. , TIDE =

TIME	SEC	DEP	TEMP	TOC	CHLOR	TKN	NH3-N	NO2	NO3	TOT-P	INO-P	CBOD5	DO	DYE	PH
	CHI	TH			PHYLL			N	N						
(HR)	(M)	(M)	(C)	(MG/L)	(UG/L)	(MG/L)	(MG/L)	(MG/L)	(MG/L)	(MG/L)	(MG/L)	(MG/L)	(MG/L)	(PPB)	
0.1	0.0	2.	23.50		7.32								6.90		
1.1	0.0	2.	23.40	7.00	8.42	0.50	0.10	0.04	0.13	0.20	0.10	1.08	6.80		
2.1	0.0	2.	23.30		8.42								6.90		
3.2	0.0	2.	23.30	8.00	13.30	0.60	0.10	0.06	0.09	0.20	0.07	1.00	7.00		
4.0	0.0	2.	23.40		11.53								7.30	0.30	
5.1	0.0	2.	23.80	10.00	15.96	0.60	0.10	0.05	0.07	0.20	0.07	1.00	6.90		
6.0	0.0	2.	23.10		15.08								7.80		
7.1	0.0	2.	23.00	11.00	19.95	0.60	0.10	0.02	0.05	0.10	0.05	1.00	7.30		
8.1	0.2	2.	23.00		21.06								7.70		7.80
9.2	0.2	2.	23.00	11.00	23.50	0.80	0.10	0.01	0.05	0.20	0.05	1.00	7.70	0.30	
10.2	0.2	2.	23.80		19.07								7.70		7.70
11.1	0.2	2.	23.70	10.00	23.28	0.60	0.10	0.02	0.05	0.20	0.07	2.00	8.00		
12.1	0.2	2.	24.10		15.96								8.30		7.80
13.1	0.3	2.	24.10	10.00	21.28	0.60	0.10	0.04	0.05	0.20	0.05	2.00	8.40		
14.2	0.3	2.	24.40		23.06								9.00		7.90
15.1	0.3	2.	24.80	9.00	24.16	0.80	0.10	0.01	0.05	0.20	0.07	2.00	10.00		

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 24 8 81 , STN = 00002, BOTTOM DEPTH = 2.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEP TH (M)	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
13.1	0.3	1.	24.20	11.00	20.84	0.70	0.10	0.01	0.05	0.20	0.05	2.43	9.90	0.30	
14.3	0.3	1.	23.80		15.30								12.00		
15.2	0.3	1.	23.70	10.00	21.73	0.80	0.10	0.01	0.05	0.20	0.05	4.00	8.90		
16.2	0.3	1.	24.50		20.17								9.80		
17.2	0.3	1.	24.50	12.00	19.73	0.70	0.10	0.01	0.05	0.20	0.04	4.00	8.90		
18.3	0.3	1.	24.70		23.94								8.00		
19.2	0.2	1.	23.70	11.00	19.73	0.70	0.10	0.01	0.05	0.20	0.05	1.80	7.10		
20.1	0.0	1.	24.30		13.08								8.00		
21.3	0.0	1.	24.50	11.00	20.17	0.80	0.10	0.01	0.05	0.20	0.04	3.00	9.10	0.30	
22.3	0.0	1.	24.10		13.30								8.10		
23.2	0.0	1.	23.70	10.00	14.19	0.70	0.10	0.02	0.05	0.20	0.07	2.00	8.20		

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 25 8 81 , STN = 00002, BOTTOM DEPTH = 2.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEPTH (M)	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
0.2	0.0	1.	23.70		17.29								7.90		
1.5	0.0	1.	23.40	3.10	9.75	0.50	0.10	0.05	0.10	0.20	0.08	1.30	7.30		
2.3	0.0	1.	23.30		7.09								7.20		
3.4	0.0	1.	23.10	11.00	17.74	0.70	0.10	0.01	0.05	0.20	0.06	1.00	7.90		
4.2	0.0	1.	23.30		17.74								7.90		
5.2	0.0	1.	20.80	10.00	20.62	0.70	0.10	0.01	0.05	0.20	0.05	2.00	7.90		
6.0	0.0	1.	23.20		23.50								7.70		
7.2	0.0	1.	20.50	11.00	25.05	0.80	0.10	0.01	0.05	0.20	0.05	2.00	7.60		
8.2	0.3	1.	22.70		24.39								7.90		7.80
9.3	0.2	1.	20.90	11.00	26.60	0.80	0.10	0.01	0.05	0.10	0.05	2.00	8.20		
10.3	0.2	1.	23.20		23.72								8.00		8.00
11.3	0.2	1.	21.30	11.00	23.50	0.70	0.10	0.01	0.05	0.10	0.05	2.00	8.00	0.30	
12.3	0.2	1.	23.90		27.05								8.30		7.70
13.3	0.2	1.	24.10	11.00	25.05	0.60	0.10	0.01	0.05	0.20	0.04	2.00	8.50	0.30	
14.3	0.2	1.	24.20		23.50								8.90		8.00
15.2	0.2	1.	24.50	13.00	28.38	0.70	0.10	0.01	0.05	0.10	0.06	3.00	9.60		

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 24 8 81 , STN = 00003, BOTTOM DEPTH = 1.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEP TH (M)	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
13.0	0.4	1.	32.00	13.00	26.60	0.80	0.10	0.01	0.05	0.20	0.05	2.10	7.10	0.03	9.80
14.0	0.4	1.	32.00		15.96								10.40	0.03	9.80
15.0	4.0	1.	32.00	11.00	31.04	0.70	0.10	0.01	0.05	0.10	0.05	3.00	11.00	0.02	9.80
16.0	0.4	1.	32.40		29.49								9.80	0.02	9.80
17.0	0.4	1.	23.10	12.00	28.60	0.80	0.10	0.01	0.05	0.10	0.05	4.00	8.90	0.02	9.80
18.0	0.4	1.	23.00		30.15								7.10	0.02	9.70
19.0	0.3	1.	24.00	13.00	28.38	0.80	0.10	0.01	0.05	0.10	0.04	2.78	7.10	0.70	8.90
19.9	0.0	1.	24.10		25.72								8.50	3.40	
21.0	0.0	1.	23.90	16.00	27.05	0.80	0.10	0.01	0.05	0.10	0.05	4.00	9.00	3.50	
21.9	0.0	1.	23.30		25.27								8.80	0.70	
23.0	0.0	1.	23.40	12.00	21.50	0.80	0.10	0.01	0.05	0.10	0.04	3.00	8.50	1.35	

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 25 8 81 , STN = 00003, BOTTOM DEPTH = 1.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEP TH (M)	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
0.0	0.0	1.	23.40										8.40	1.05	
1.0	0.0	1.	23.40	13.00	24.16	0.70	0.10	0.01	0.05	0.10	0.04	2.48	8.10	0.04	
2.0	0.0	1.	23.30		23.50								8.00	0.05	
3.0	0.0	1.	23.00	12.00	20.40	0.70	0.10	0.01	0.05	0.10	0.05	2.00	7.60	0.07	
4.1	0.0	1.	24.90		27.49								7.50	0.91	
5.2	0.0	1.	22.30	11.00	24.61	0.80	0.10	0.01	0.05	0.10	0.05	3.00	7.20	0.73	
6.0	0.4	1.	22.30		26.16								6.70	0.58	7.50
7.0	0.3	1.	22.30	12.00	31.48	0.70	0.10	0.01	0.05	0.10	0.05	2.00	7.20	1.80	7.30
8.0	0.3	1.	23.20		26.60								7.30	2.01	7.40
9.0	0.3	1.	23.70	12.00	30.15	0.80	0.10	0.01	0.05	0.10	0.05	3.00	7.60	1.60	7.90
10.0	0.3	1.	23.90		31.92								8.20	2.10	8.30
11.0	0.3	1.	24.20	12.00	25.27	0.80	0.10	0.01	0.05	0.11	0.05	4.00	8.70	1.60	8.70
12.0	0.3	1.	24.25		30.82								8.50	0.89	8.90
13.0	0.3	1.	24.50	13.00	31.04	0.70	0.10	0.01	0.05	0.10	0.03	3.00	9.00	0.78	9.30
14.0	0.3	1.	24.65		20.62								8.30	0.82	9.40
15.0	0.3	1.	24.75	13.00	26.60	0.80	0.10	0.01	0.05	0.10	0.05	3.00	9.70	3.30	9.70

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 24 8 81 , STN = 00004, BOTTOM DEPTH = 2.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEP TH (M)	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
13.3	0.4	1.	32.00	14.00	31.92	0.70	0.10	0.01	0.05	0.10	0.04	2.78	9.60	0.02	8.70
14.1	0.4	1.	32.00		27.27								10.20	0.04	9.50
15.1	0.3	1.	32.00	13.00	22.17	0.70	0.10	0.01	0.05	0.10	0.04	4.00	11.00	1.25	9.50
16.1	0.4	1.	32.00		25.49								9.80	1.62	9.40
17.1	0.4	1.	24.80	12.00	28.38	0.60	0.10	0.01	0.05	0.10	0.04	4.00	8.80	1.60	9.90
18.0	0.3	1.	24.90		25.27								9.10	1.45	9.30
19.0	0.3	1.	24.50	13.00	25.27	0.70	0.10	0.01	0.05	0.20	0.04	3.00	9.20	0.27	7.90
20.1	0.0	1.	24.40		19.73								8.80	0.20	
21.1	0.0	1.	23.60	12.00	20.17	0.70	0.10	0.01	0.05	0.10	0.04	4.00	8.70	0.79	
22.0	0.0	1.	24.30										8.80	1.60	
23.1	0.0	1.	24.30	13.00	25.05	0.80	0.10	0.01	0.05	0.10	0.04	3.00	9.10	5.00	

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 25 8 81 , STN = 00004, BOTTOM DEPTH = 2.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEP TH (M)	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
0.2	0.0	1.	23.80		27.93								8.50	4.20	
1.2	0.0	1.	23.50	13.00	26.60	0.80	0.10	0.01	0.05	0.10	0.04	2.63	7.80	2.50	
2.1	0.0	1.	23.40		25.05								7.70	2.10	
3.2	0.0	1.	23.30	13.00	25.72	0.70	0.10	0.01	0.05	0.10	0.05	2.00	7.70	3.60	
4.2	0.0	1.	23.40										7.70	3.80	
5.2	0.0	1.	23.00	12.00	22.61	0.70	0.10	0.01	0.05	0.10	0.05	3.00	6.80	1.15	
6.2	0.3	1.	23.00		26.16								6.70	1.40	7.40
7.1	0.2	1.	23.00	11.00	28.82	0.70	0.10	0.01	0.05	0.10	0.03	3.00	6.60	2.80	7.30
8.2	0.0	1.	23.25		23.06								6.90	2.10	7.30
9.2	0.2	1.	23.40	15.00	28.16	0.70	0.10	0.01	0.05	0.10	0.03	3.00	7.80	3.60	7.50
10.2	0.3	1.	23.60		28.16								7.10	3.30	7.30
11.2	0.3	1.	24.30	13.00	26.38	0.70	0.10	0.01	0.05	0.10	0.03	3.00	8.00	1.10	7.90
12.2	0.2	1.	24.20		24.61								8.20	2.10	7.70
13.2	0.2	1.	24.90	13.00	24.39	0.70	0.10	0.01	0.05	0.10	0.03	5.00	9.20	2.90	8.90
15.1	0.2	1.	24.80		29.71								8.80	3.10	8.90
15.1	0.2	1.	24.90	12.00	30.59	0.80	0.10	0.01	0.05	0.10	0.03	4.00	9.80	1.90	9.70

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 24 8 81 , STN = 00005, BOTTOM DEPTH = 2.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEP TH (M)	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
13.5	0.4	1.	32.00	14.00	27.27	0.70	0.10	0.01	0.05	0.10	0.05	3.23	9.30	0.03	9.30
14.2	0.3	1.	32.00		21.95								10.20	0.03	9.00
15.3	0.3	1.	32.00	12.00	27.05	0.70	0.10	0.01	0.05	0.10	0.04	4.00	8.80	0.03	9.00
16.2	0.0	1.	24.80		22.39								8.60	0.03	8.70
17.2	0.4	1.	24.50	11.00	23.28	0.70	0.10	0.01	0.05	0.10	0.04	4.00	8.60	0.02	7.30
18.1	0.3	1.	24.30		29.33								8.70	0.02	7.40
19.2	0.2	1.	24.10	13.00	16.41	0.60	0.10	0.01	0.05	0.10	0.04	2.50	8.20	0.03	7.50
20.2	0.0	1.	24.10		25.05								8.20	0.03	
21.2	0.0	1.	24.00	12.00		0.60	0.10	0.01	0.05	0.10	0.05	3.00	7.70	0.04	
22.1	0.0	1.	23.90		25.49								7.80	0.17	
23.3	0.0	1.	23.70	13.00	25.05	0.60	0.10	0.01	0.05	0.10	0.05	3.00	7.80	0.23	

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 25 8 81 , STN = 00005, BOTTOM DEPTH = 2.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEPTH (M)	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
0.2	0.0	1.	24.20		22.17								7.60	0.29	
1.3	0.0	1.	23.40	13.00		0.70	0.10	0.01	0.05	0.10	0.04	3.20	7.20	6.60	
2.2	0.0	1.	23.40		23.50									0.27	7.30
3.4	0.0	1.	23.50	12.00	21.06	0.70	0.10	0.01	0.05	0.10	0.03	3.00	7.00	3.15	
4.3	0.0	1.	23.50		22.39								6.70	1.65	
5.3	0.0	1.	23.40	11.00	17.74	0.70	0.10	0.01	0.05	0.10	0.03	2.00	6.50	0.78	
6.4	0.2	1.	23.30		20.62								6.20	0.53	7.20
7.2	0.2	1.	23.20	10.00	21.73	0.60	0.10	0.01	0.05	0.10	0.02	2.00	6.10	0.19	7.10
8.3	0.3	1.	23.20		23.50								6.00	0.07	7.30
9.3	0.3	1.	23.50	10.00	25.49	0.60	0.10	0.01	0.05	0.10	0.03	2.00	6.40	0.06	6.80
10.3	0.3	1.	23.85		20.84								7.10	0.13	7.00
11.3	0.3	1.	24.90	13.00	22.17	0.70	0.10	0.01	0.05	0.10	0.02	3.00	8.10	0.22	7.40
12.3	0.2	1.	25.25		23.50								8.60	1.60	7.50
13.3	0.2	1.	25.70	12.00		0.60	0.10	0.01	0.05	0.10	0.03	3.00	9.30	0.98	7.80
14.2	0.2	1.	25.90		21.06								9.50	1.15	7.80
15.2	0.2	1.	25.45	13.00	21.73	0.70	0.10	0.01	0.05	0.10	0.02	4.00	9.50		8.30

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 24 8 81 , STN = 00006, BOTTOM DEPTH = 2.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEP TH (M)	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
13.1	0.4	1.	25.00	11.00	17.29	0.70	0.10	0.01	0.05	0.10	0.04	2.33	7.60	0.02	7.00
14.2	0.3	1.	25.00		21.06								7.30		6.90
15.3	0.3	1.	24.00	12.00	20.17	0.60	0.10	0.01	0.05	0.10		3.00	8.60		
16.2	0.4	1.	24.50		23.28								9.80	0.02	6.90
17.2	0.4	1.	24.50	11.00	17.96	0.70	0.10	0.01	0.05	0.10	0.07	3.00	9.60		
18.3	0.3	1.	24.40		16.85								9.70		6.80
19.3	0.0	1.	24.50	11.00	12.41	0.50	0.10	0.01	0.05	0.10	0.03	2.33	9.20		
20.2	0.0	1.	24.30		14.63								8.90		
21.3	0.0	1.	24.00	11.00	17.74	0.70	0.10	0.01	0.05	0.10	0.07	3.00	8.70		
22.3	0.0	1.	24.00										8.60		
23.3	0.0	1.	23.80	13.00	19.29	0.70	0.10	0.01	0.05	0.10	0.03	3.00	8.40		

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 25 8 81 , STN = 00006, BOTTOM DEPTH = 2.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEPTH (M)	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
1.3	0.0	1.	23.60	13.00	18.62	0.70	0.10	0.01	0.05	0.10	0.04	2.73	8.40	0.01	
2.4	0.0	1.	24.00		11.97								8.10		
3.3	0.0	1.	24.00	12.00	19.73	0.70	0.10	0.01	0.05	0.10	0.02	2.00	7.90	0.01	
4.2	0.0	1.	24.00		18.62								7.50		
5.4	0.4	1.	23.00	12.00	10.42	0.90	0.20	0.01	0.05	0.10	0.05	2.00	7.20		
6.4	0.4	1.	22.90		21.28								6.80		6.80
7.4	0.3	1.	27.00	10.00	24.39	0.60	0.10	0.01	0.05	0.10	0.02	2.00	6.30	0.01	6.70
8.4	0.4	1.	23.00		23.94								5.90		6.70
10.3	0.5	1.	24.10		23.94								6.30		
11.5	0.3	1.	25.30	10.00	28.38	0.70	0.10	0.01	0.05	0.10	0.03	2.00	7.80		
12.4	0.3	1.	24.60		24.61								7.90		6.80
13.4	0.3	1.	24.60	12.00	23.94	0.60	0.10	0.01	0.05	0.10	0.02	3.00	7.90		
14.2	0.1	1.	24.70		27.05								8.10		6.70
15.3	0.4	1.	24.50	11.00	29.26	0.70	0.10	0.01	0.05	0.10	0.02	3.00	7.90		

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 24 8 81 , STN = 00007, BOTTOM DEPTH = 2.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEP TH (M)	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
13.0	0.6	1.	25.30	12.00	9.75	0.50	0.10	0.01	0.05	0.10	0.02	2.80	8.80		6.70
14.0	0.5	1.	25.50		20.40								7.60	0.02	6.90
15.0	0.5	1.	26.00	11.00	13.97	0.50	0.10	0.01	0.05	0.10	0.02	3.00	5.20		
16.1	0.5	1.	23.10		12.41								5.10		6.90
17.0	0.5	1.	23.00	11.00	8.87	0.50	0.10	0.01	0.05	0.10	0.02	3.00	6.50		
18.1	0.5	1.	22.20		6.21								6.20		7.00
19.1	0.0	1.	22.70	12.00	11.97	0.50	0.10	0.01	0.05	0.10	0.02	2.33	6.60	0.01	
20.0	0.0	1.	22.80		10.86								6.80		
21.0	0.0	1.	23.00	10.00	11.31	0.50	0.10	0.01	0.05	0.10	0.02	3.00	5.70	0.01	
22.0	0.0	1.	22.50		11.53								5.50		
23.0	0.0	1.	22.20	11.00	13.08	0.50	0.10	0.01	0.05	0.10	0.02	2.00	6.30		

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 25 8 81 , STN = 00007, BOTTOM DEPTH = 2.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEPTH (M)	TEMP (C)	TOC (MG/L)	CHLORPHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
1.0	0.0	1.	22.50	9.00	13.52	0.60	0.10	0.01	0.05	0.10	0.03	1.88	6.60		
2.1	0.0	1.	23.00		11.08								6.90		
3.0	0.0	1.	24.00	9.00	11.75	0.60	0.10	0.01	0.05	0.10	0.02	2.00	7.30		
4.0	0.0	1.	23.50		11.64								7.60		
5.0	0.5	1.	22.60	9.00	10.86	0.50	0.10	0.01	0.05	0.10	0.01	2.00	6.20		
6.0	0.5	1.	22.70		12.64								6.40		6.70
7.1	0.6	1.	22.90	9.00	15.96	0.50	0.10	0.01	0.05	0.10	0.02	2.00	4.10		6.70
8.2	0.6	1.	22.90		18.40								3.60		6.70
9.1	0.6	1.	23.50	10.00	17.07	0.50	0.10	0.01	0.05	0.10	0.02	1.00	6.30		6.70
10.1	0.6	1.	24.10		14.41								6.70		6.70
11.2	0.6	1.	24.60	10.00	17.74	0.50	0.10	0.01	0.05	0.10	0.02	3.00	7.30	0.01	6.70
12.1	0.5	1.	24.70		17.51								6.80		6.70
13.1	0.5	1.	24.60	10.00	17.96	0.50	0.10	0.01	0.05	0.10	0.02	3.00	6.90		
14.1	0.5	1.	24.40		17.29								6.80		6.70
15.1	0.5	1.	24.20	10.00	13.52	0.50	0.10	0.01	0.05	0.10	0.02	3.00	7.00		

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 24 8 81 , STN = 00008, BOTTOM DEPTH = 0.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEP TH (M)	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
13.1	0.0	0.	20.50	6.00	0.33	0.40	0.20	0.01	0.18	0.10	0.01	0.75	9.40		6.70
14.1	0.0	0.	21.20		0.49								11.50		7.20
15.1	0.0	0.	21.10	5.00	0.53	0.40	0.10	0.01	0.21	0.10	0.01	1.00	9.60		7.20
16.1	0.0	0.	22.00		0.73								9.90		7.20
17.1	0.0	0.	21.90	6.00	0.53	0.50	0.20	0.01	0.21	0.10	0.01	1.00	10.70		7.20
18.1	0.0	0.	23.80		0.44								11.00		7.20
19.1	0.0	0.	28.00	5.00	0.11	0.40	0.20	0.01	0.18	0.10	0.01	0.80	10.60		
20.1	0.0	0.	24.00		0.53								11.00		
21.2	0.0	0.	22.40	6.00	0.64	0.50	0.20	0.01	0.21	0.10	0.01	1.00	9.80		
22.1	0.0	0.	21.80		0.27								9.30		
23.1	0.0	0.	21.20	5.00	0.75	0.40	0.20	0.01	0.20	0.10	0.01	1.00	9.00		

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 25 8 81 , STN = 00008, BOTTOM DEPTH = 0.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEP TH (M)	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
0.1	0.0	0.	21.60		0.64								9.00		
1.1	0.0	0.	21.30	6.00	0.53	0.40	0.20	0.01	0.21	0.10	0.01	0.65	8.70		
2.1	0.0	0.	20.90										8.10		
3.2	0.0	0.	21.00	4.00	0.80	0.60	0.20	0.01	0.21	0.10	0.01	1.00	7.00		
4.2	0.0	0.	21.00		0.42								7.90		
5.1	0.0	0.	20.50	8.00	1.77	0.50	0.20	0.01	0.21	0.10	0.01	1.00	7.60		
6.1	0.0	0.	20.80		0.75								7.00		
7.2	0.0	0.	20.20	5.00	1.77		0.20	0.01	0.22	0.10	0.01	1.00	7.00		7.00
8.1	0.0	0.			2.26								6.80		7.00
9.1	0.0	0.	20.50	5.00	2.26	0.20	0.10	0.01	0.05	0.10	0.01	1.00	6.80		7.00
10.1	0.0	0.	21.00		2.79								7.60		7.00
11.3	0.0	0.	23.00	6.00	5.76	1.00	0.30	0.01	0.21	0.10	0.01	2.00	7.40		7.00
12.0	0.0	0.	22.80		2.77								8.60		7.00
13.1	0.0	0.	22.50	5.00	1.00	0.30	0.20	0.01	0.21	0.10	0.01	1.00	8.30		7.00
14.1	0.0	0.	23.20		10.64								9.50		7.10
15.1	0.0	0.		9.70	1.20	0.60	0.20	0.01	0.22	0.10	0.01	1.00	9.70		7.00

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                              AQUIA CREEK INTENSIVE WATER QUALITY DATA

                     D M Y = 24  8 81 , STN = 00009, BOTTOM DEPTH =  0.00 M. , TIDE =
TIME SEC  DEP  TEMP   TOC  CHLOR  TKN  NH3-N  NO2   NO3  TOT-P INO-P CBOD5  DO    DYE    PH
     CHI  TH               PHYLL                N     N
(HR) (M)  (M)   (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

15.0 0.0   0.  22.40 16.00        12.40  9.00  0.06  0.21  5.10  5.00  2.25  6.30         7.50
15.0 0.0   0.  22.90 19.00        12.70  9.00  0.04  0.18  5.10  5.00  2.98  6.30         7.50
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                              AQUIA CREEK INTENSIVE WATER QUALITY DATA

                     D M Y = 25  8 81 , STN = 00009, BOTTOM DEPTH =  0.00 M. , TIDE =
TIME SEC  DEP  TEMP   TOC  CHLOR  TKN  NH3-N  NO2   NO3  TOT-P INO-P CBOD5  DO    DYE    PH
     CHI  TH               PHYLL                N     N
(HR) (M)  (M)   (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

 0.3 0.0   0.  21.30 21.00        13.00  9.50  0.05  0.15  5.40  5.00  2.50  6.30
15.0 0.0   0.  22.00 17.00        13.20 10.00  0.05  0.15  5.20  5.00  2.30  6.40         7.20
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AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 24 8 81 , STN = 00010, BOTTOM DEPTH = 0.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEP TH (M)	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
11.7	0.0	0.		8.00		0.10	0.10	0.01	0.05	0.10	0.01	1.00			
13.4	0.0	0.	20.00	5.00	0.27	0.20	0.10	0.01	0.05	0.10	0.01	0.80	9.40		7.20
14.3	0.0	0.	19.10	5.00	0.53	0.10	0.10	0.01	0.05	0.10	0.01	1.00	8.90		7.20
15.4	0.0	0.	20.00	5.00	0.64	0.10	0.10	0.01	0.05	0.10	0.01	1.00	8.90		7.20
16.3	0.0	0.	20.80		0.13								8.70		6.70
17.3	0.0	0.	20.40	6.00	0.29	0.20	0.10	0.01	0.05	0.10	0.01	1.00	8.50		6.70
18.3	0.0	0.	20.20		0.29								8.50		6.70
19.3	0.0	0.	20.90	6.00	0.55	0.20	0.10	0.01	0.05	0.10	0.03	0.70	8.00		
20.3	0.0	0.	20.20		0.80								8.00		
21.4	0.0	0.	20.10	8.00	0.44	0.30	0.10	0.01	0.05	0.10	0.06	1.00	7.80		
22.3	0.0	0.	20.00		0.24								7.80		
23.3	0.0	0.	19.90	6.00	0.62	0.40	0.20	0.01	0.05	0.20	0.16	1.00	7.90		

AQUIA CREEK INTENSIVE WATER QUALITY DATA

D M Y = 25 8 81 , STN = 00010, BOTTOM DEPTH = 0.00 M. , TIDE =

TIME (HR)	SEC CHI (M)	DEP TH (M)	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	TKN (MG/L)	NH3-N (MG/L)	NO2 N (MG/L)	NO3 N (MG/L)	TOT-P (MG/L)	INO-P (MG/L)	CBOD5 (MG/L)	DO (MG/L)	DYE (PPB)	PH
0.3	0.0	0.	19.80		0.33								8.00		
1.4	0.0	0.	19.60	5.00	0.73	0.20	0.10	0.01	0.05	0.10	0.04	0.73	7.80		
2.3	0.0	0.	19.30		0.62								7.90		
3.4	0.0	0.	19.10	5.00	0.49	0.10	0.10	0.01	0.05	0.10	0.02	1.00	8.10		
4.3	0.0	0.	19.00		0.69								7.90		
5.3	0.0	0.	18.80	6.00	0.89	0.10	0.10	0.01	0.05	0.10	0.01	1.00	8.10		
6.2	0.0	0.	18.30		0.35								8.00		
7.3	0.0	0.	18.30	5.00	1.33	0.10	0.10	0.01	0.05	0.10	0.01	1.00	8.40		7.10
8.3	0.0	0.	18.60		1.24								8.30		7.10
9.3	0.0	0.	19.10	5.00	1.40	0.50	0.30	0.01	0.05	0.10	0.01	1.00	8.60		7.10
10.2	0.0	0.	19.90		1.06								8.00		7.10
11.4	0.0	0.	20.50	6.00	0.98	0.20	0.10	0.01	0.05	0.10	0.01	1.00	8.60		7.30
12.2	0.0	0.	21.10		1.64								8.60		7.40
13.3	0.0	0.	21.10	5.00	0.75	0.20	0.10	0.01	0.05	0.10	0.01	1.00	8.50		7.20
14.2	0.0	0.	20.90		1.17								8.40		7.10
15.3	0.0	0.	21.20	6.00	1.75	0.10	0.10	0.01	0.05	0.10	0.01	1.00	8.50		7.20

Appendix B. Slackwater and Intensive Survey Data, Adjusted for Model Use.

AQUIA CREEK SLACK WATER DATA (CORRECTED).

D M Y= 26 5 81 ,CRUISE= OSAQ1,RIVER= AQ,TIDE= H

TIME	STN	SEC CHI DISK	BOT TOM DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	ORG-N (MG/L)	NH3-N (MG/L)	N2+N3 N (MG/L)	NO3 N (MG/L)	ORG-P (MG/L)	INO-P (MG/L)	UBOD (MG/L)	DO (MG/L)	DYE (PPB)	PH
11.0	00001	0.3	3.	21.80	9.00	17.70	0.47	0.01	0.82	0.81	0.04	0.04	3.62	9.70		9.50
11.1	00002	0.3	2.	22.00	10.00	32.80	0.47	0.10	0.29	0.28	0.03	0.04	5.65	10.60		9.80
*11.5	00003	0.4	1.	25.20	22.00	16.40	6.39	2.50	2.25	0.95	0.38	5.50	11.01	10.60		9.80
11.7	00004	0.4	2.	25.10	7.00	14.80	0.60	0.10	0.09	0.08	0.06	0.03	8.62	8.40		8.80
12.0	00005	0.0	2.	26.20	14.00	12.20	0.61	0.10	0.09	0.08	0.06	0.03	11.48	7.80		7.30
12.5	00006	0.0	2.	24.90	11.00		0.50	0.10	0.07	0.06	0.04	0.05	11.27	7.90		7.60
12.8	00007	0.5	2.	26.10	14.00		0.30	0.10	0.07	0.06	0.07	0.02	8.70	11.00		8.20
12.1	00008	0.0	0.	23.50	7.00	1.40	0.29	0.10	0.11	0.10	0.08	0.02	2.41	7.20		7.00
11.3	00009	0.0	0.	20.50	11.00		0.60	0.10	0.07	0.06	0.06	0.03	10.83	6.10		7.00
11.6	00010	0.0	0.	22.00	6.00	3.50	0.00	0.10	0.07	0.06	0.09	0.01	2.18	7.60		7.00

*sample mislabeling is suspected.

AQUIA CREEK SLACK WATER DATA (CORRECTED).

D M Y= 11 6 81 ,CRUISE= OSAQ2,RIVER= AQ,TIDE= L

TIME	STN	SEC CHI DISK	BOT TOM DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	ORG-N (MG/L)	NH3-N (MG/L)	N2-N3 N (MG/L)	NO3 N (MG/L)	ORG-P (MG/L)	INO-P (MG/L)	BODU (MG/L)	DO (MG/L)	DYE (PPB)	PH
8.0	00001	0.3	3.	25.00	9.00	19.20	0.47	0.10	0.08	0.07	0.03	0.05	0.42	6.20		7.60
8.3	00002	0.3	2.	25.10	9.00	18.60	0.37	0.10	0.06	0.05	0.04	0.04	3.05	6.70		7.70
8.5	00003	0.4	1.	26.00	11.00	20.70	0.56	0.10	0.06	0.05	0.04	0.04	2.82	5.20		7.50
9.0	00004	0.3	2.	25.10	11.00	20.50	0.46	0.10	0.06	0.05	0.04	0.04	0.27	6.90		7.10
9.1	00005	0.3	2.	25.00	9.00	22.90	0.44	0.30	0.07	0.05	0.04	0.04	2.57	5.20		6.60
9.4	00006	0.3	2.	25.40	8.00	21.20	0.45	0.30	0.08	0.06	0.04	0.04	0.19	5.10		6.50
9.6	00007	0.5	2.	26.10	8.00	17.00	0.68	0.20	0.08	0.07	0.06	0.02	1.00	2.50		6.40
10.0	00008	0.0	0.	23.00	6.00	1.60	0.29	0.20	0.10	0.09	0.07	0.03	1.11	7.10		7.10
9.5	00009	0.0	0.	21.00	10.00	1.50	3.99	12.50	0.33	0.21	0.00	4.80	6.90	7.30		8.80
8.0	00010	0.0	0.	19.50	5.00	0.60	0.20	0.10			0.09	0.01	1.42	8.40		7.30

AQUIA CREEK SLACK WATER DATA (CORRECTED).

D M Y= 23 6 81 ,CRUISE= OSAQ3,RIVER= AQ,TIDE=

TIME	STN	SEC CHI DISK	BOT TOM DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	ORG-N (MG/L)	NH3-N (MG/L)	N2-N3 N (MG/L)	NO3 N (MG/L)	ORG-P (MG/L)	INO-P (MG/L)	BODU (MG/L)	DO (MG/L)	DYE (PPB)	PH
4.9	00001	0.0	3.	26.30	11.00		0.65	0.10	0.06	0.05	0.01	0.05	1.36	8.30		8.50
5.2	00002	0.0	2.	26.00	15.00		1.10		0.06	0.05	0.10	0.06	2.98	7.50		7.90
5.5	00003	0.2	1.	25.90	14.00		0.75	0.10	0.06	0.05	0.00	0.06	4.06	5.80		7.10
5.8	00004	0.2	2.	26.50	13.00	36.00	0.75	0.10	0.07	0.05	0.00	0.06	2.39	5.10		7.00
6.0	00005	0.2	2.	26.80	12.00		0.35	0.20	0.06	0.04	0.01	0.05	1.10	4.20		6.60
6.3	00006	0.2	2.	26.80	11.00		0.35	0.10	0.06	0.05	0.02	0.04	1.10	4.40		6.60
6.5	00007	0.2	2.	26.90	10.00		0.35	0.20	0.06	0.05	0.03	0.03	0.00	5.20		6.90
4.9	00008	0.0	0.	25.50	9.00		0.15	0.10	0.09	0.08	0.02	0.04	0.00	6.30		7.50
6.0	00009	0.0	0.	22.50	14.00		1.05	1.00	1.12	1.10	0.16	4.20	0.00	6.90		7.50
4.7	00010	0.0	0.	20.00	7.00		0.00	0.10	0.11	0.10	0.03	0.03	0.00	8.00		7.20

AQUIA CREEK SLACK WATER DATA (CORRECTED).

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                           D M Y=  7  7 81 ,CRUISE= OSAQ4,RIVER= AQ,TIDE= L
TIME STN    SEC  BOT  TEMP    TOC  CHLOR ORG-N NH3-N N2-N3  NO3  ORG-P INO-P BODU   DO    DYE    PH
            CHI  TOM               PHYLL              N     N
           DISK DEPTH  (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

5.5 00001  0.2   3.  26.00 13.00        0.41  0.10              0.04  0.05  1.12  7.40         7.90
5.9 00002  0.3   2.  26.00 17.00 19.66  0.56  0.10  0.06  0.05  0.04  0.04  2.94  6.95         7.20
6.4 00003  0.2   2.  26.00 13.00 17.28  0.38  0.10  0.06  0.05  0.05  0.03  3.20  3.90         7.00
6.5 00004  0.2   1.  26.00 15.00 15.98  0.39  0.10  0.06  0.05  0.05  0.03  3.35  5.00         6.80
7.0 00005  0.2   2.  31.00 13.00        0.31  0.10  0.06  0.05  0.06  0.03  3.69  5.40         6.70
7.2 00006  0.2   2.  31.00 10.00        0.70        0.06  0.05  0.05  0.04  3.17  5.30         6.30
7.7 00007  0.4   3.  25.50 11.00 10.15  0.33  0.10  0.06  0.05  0.08  0.01  2.85  5.00         6.80
6.7 00008  0.0   0.  25.50  8.00  1.77  0.29  0.10  0.06  0.05  0.09  0.01  1.68  7.50         6.50
7.2 00009  0.0   0.  24.00 15.00        1.31  4.00  1.02  0.90  0.09  5.00  5.48  7.20         1.90
6.0 00010  0.0   0.  20.00  5.00        0.01  0.10  0.06  0.05  0.08  0.01  0.00  7.60         6.50
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AQUIA CREEK SLACK WATER DATA (CORRECTED).

D M Y= 23 7 81 ,CRUISE= OSAQ5,RIVER= AQ,TIDE= H

TIME	STN	SEC CHI DISK	BOT TOM DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	ORG-N (MG/L)	NH3-N (MG/L)	N2-N3 N (MG/L)	NO3 N (MG/L)	ORG-P (MG/L)	INO-P (MG/L)	BODU (MG/L)	DO (MG/L)	DYE (PPB)	PH
10.1	00001	0.1	3.	27.00	12.00	29.16	0.70	0.10	0.06	0.05	0.02	0.05	4.65	9.00		8.50
10.4	00002	0.1	2.	27.00	11.00	28.08	0.60	0.10	0.06	0.05	0.14	0.03	5.02	10.00		8.50
10.7	00003	0.2	1.	27.00	11.00	29.81	0.49	0.10	0.06	0.05	0.02	0.05	4.96	7.20		7.70
11.0	00004	0.2	2.	27.00	15.00	28.08	0.60	0.10	0.06	0.05	0.00	0.07	8.49	7.30		7.70
11.1	00005	0.1	2.	27.00	17.00	24.84	0.53	0.10	0.06	0.05	0.02	0.06	7.37	7.30		7.80
11.5	00006	0.1	2.	28.00	17.00	19.44	0.46	0.10	0.06	0.05	0.04	0.04	5.53	6.60		7.30
11.7	00007	0.1	2.	29.00	13.00	13.61	0.40	0.10	0.06	0.05	0.06	0.03	6.18	7.20		7.20
11.5	00008	0.0	0.	25.00	7.00		0.06	0.10	0.13	0.12	0.07	0.01	0.37	8.80		6.70
10.2	00009	0.0	0.	23.50	14.00	1.04	0.79	0.60	0.71	0.70	0.10	5.00		7.00		6.90
11.0	00010	0.0	0.	23.50	7.00	2.35	0.08	0.10	0.06	0.05	0.09	0.01	2.31	8.80		6.60

AQUIA CREEK SLACK WATER DATA (CORRECTED).

```
                        D M Y=  5  8 81 ,CRUISE= OSAQ6,RIVER= AQ,TIDE= H
TIME STN    SEC  BOT  TEMP   TOC  CHLOR ORG-N NH3-N N2-N3  NO3  ORG-P INO-P BODU   DO    DYE    PH
            CHI  TOM              PHYLL               N     N
            DISK DEPTH (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

10.3 00001  0.3   3.  28.60  9.00 19.01  0.37  0.10  0.16  0.15  0.01  0.07  0.44  7.80         7.90
10.5 00002  0.3   2.  29.00 11.00 22.68  0.34  0.10  0.06  0.05  0.02  0.06  2.60  8.70         8.00
10.9 00003  0.2   1.  29.00 15.00 14.26  0.60  0.10  0.06  0.05  0.04  0.05  6.11  8.30         8.10
11.1 00004  0.2   2.  29.10 11.00 27.43  0.31  0.10  0.06  0.05  0.04  0.03  4.63  7.60         6.20
11.3 00005  0.2   2.  28.00 12.00 22.25  0.34  0.10  0.06  0.05  0.04  0.04  2.64  5.40         6.20
11.6 00006  0.3   2.  27.80  9.00 14.04  0.30  0.10  0.06  0.05  0.06  0.03  0.53  5.70         6.20
12.0 00007  0.3   2.  27.80  9.00 17.93  0.00  0.10  0.06  0.05  0.07  0.01  1.20  6.40         6.50
12.8 00008  0.0   0.  27.70  8.00  0.48  0.30  0.10  0.06  0.05  0.09  0.01  2.34  6.90         6.60
11.0 00009  0.0   0.  26.50 12.00        0.69  0.50  2.21  2.20  0.18  4.00  0.00  6.60         6.90
10.6 00010  0.0   0.  23.00  6.00  0.69  0.00  0.10  0.06  0.05  0.08  0.02  1.08  8.20         6.30
```

AQUIA CREEK SLACK WATER DATA (CORRECTED).

```
                        D M Y= 23  8 81 ,CRUISE= OSAQ7,RIVER= AQ,TIDE=
TIME STN    SEC  BOT  TEMP   TOC  CHLOR ORG-N NH3-N N2-N3  NO3  ORG-P INO-P BODU   DO    DYE    PH
            CHI  TOM              PHYLL               N     N
            DISK DEPTH (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

12.3 00009  0.0   0.  21.00                                                      6.50         7.70
12.5 00008  0.0   0.  21.00                                                      8.60         6.60
11.7 00010  0.0   0.  19.10                                                      8.80         6.70
```

AQUIA CREEK SLACK WATER DATA (CORRECTED).

D M Y= 21 9 81 ,CRUISE= OSA11,RIVER= AQ,TIDE= H

TIME	STN	SEC CHI DISK	BOT TOM DEPTH	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	ORG-N (MG/L)	NH3-N (MG/L)	N2-N3 N (MG/L)	NO3 N (MG/L)	ORG-P (MG/L)	INO-P (MG/L)	BODU (MG/L)	DO (MG/L)	DYE (PPB)	PH
11.1	00001	0.5	3.	20.85	8.00		0.36	0.10	0.25	0.22	0.02	0.07	4.58	8.50		8.00
11.4	00002	0.5	2.	20.50	11.00		0.56	0.10	0.06	0.05	0.03	0.06	10.67	10.65		8.20
11.7	00003	0.2	2.	20.55	12.00		0.56	0.10	0.06	0.05	0.05	0.04	12.46	10.50		8.50
12.0	00004	0.3	2.	20.90	12.00		0.56	0.10	0.06	0.05	0.05	0.04	10.28	10.95		8.10
12.2	00005	0.3	3.	21.00	11.00		0.56	0.10	0.06	0.05	0.06	0.03	10.15	10.80		7.70
12.5	00006	0.4	2.	20.00	10.00		0.36	0.30	0.09	0.06	0.04	0.05	7.07	7.80		7.00
12.0	00009	0.0	0.	19.50	11.00		4.86	9.50	0.21	0.13	0.09	5.50	2.78	7.50		2.40
12.2	00010	0.0	0.	16.00	5.00		0.00	0.10	0.06	0.05	0.08	0.01	1.93	10.40		6.70
12.7	00007	0.6	2.	20.00	10.00		0.36	0.10	0.06	0.05	0.06	0.03	7.07	6.80		6.80
13.0	00008	0.0	0.	19.50	9.00		0.16	0.10	0.06	0.05	0.08	0.01	1.93	10.30		8.70

AQUIA CREEK INTENSIVE DATA (CORRECTED).

D M Y= 24 8 81 STN = 00001 BOTTOM DEPTH = 3.00,CRUISE= AQ881,RIVER= AQ,TIDE=

TIME	SEC CHI DISK	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	ORG-N (MG/L)	NH3-N (MG/L)	N2+N3 N (MG/L)	NO3 N (MG/L)	ORG-P (MG/L)	INO-P (MG/L)	UBOD (MG/L)	DO (MG/L)	DYE (PPB)	PH
13.0	0.4	24.00	8.00	10.64	0.33	0.10	0.19	0.12	0.10	0.09	1.71	7.40	0.03	
14.1	0.3	23.80		13.97								8.50		
15.1	0.3	23.60	13.00	17.74	0.38	0.10	0.07	0.05	0.13	0.05	3.15	7.20		
16.1	0.3	25.00		20.62								11.80		
17.1	0.2	24.50	12.00	15.96	0.49	0.10	0.06	0.05	0.12	0.06	8.49	8.00	0.30	
18.2	0.2	24.50		21.73								8.10		
19.1	0.2	24.50	45.00	19.95	0.46	0.10	0.06	0.05	0.13	0.05	4.83	7.50	0.30	
20.3	0.0	24.70		11.08								7.20		
21.0	0.0	24.30	10.00	15.30	0.49	0.10	0.06	0.05	0.12	0.06	3.42	8.10		
22.1	0.0	23.80		8.42								7.50	0.03	
23.1	0.0	23.50	9.00	10.42	0.33	0.10	0.18	0.11	0.09	0.10	1.40	7.00		

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                 AQUIA CREEK INTENSIVE DATA (CORRECTED).

        D M Y= 25   8 81 STN = 00001 BOTTOM DEPTH =  3.00,CRUISE= AQ881,RIVER= AQ,
 TIME   SEC  TEMP   TOC CHLOR ORG-N NH3-N N2-N3   NO3 ORG-P INO-P  BODU    DO   DYE    PH
        CHI             PHYLL             N     N
       DISK   (C)(MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

  0.1   0.0 23.50        7.32                                           6.90
  1.1   0.0 23.40  7.00  8.42  0.34  0.10  0.17  0.13  0.09  0.10  1.83  6.80
  2.1   0.0 23.30        8.42                                           6.90
  3.2   0.0 23.30  8.00 13.30  0.41  0.10  0.15  0.09  0.12  0.07  1.08  7.00
  4.0   0.0 23.40       11.53                                           7.30  0.30
  5.1   0.0 23.80 10.00 15.96  0.39  0.10  0.12  0.07  0.11  0.07  0.78  6.90
  6.0   0.0 23.10       15.08                                           7.80
  7.1   0.0 23.00 11.00 19.95  0.36  0.10  0.07  0.05  0.03  0.05  0.33  7.30
  8.1   0.2 23.00       21.06                                           7.70        7.80
  9.2   0.2 23.00 11.00 23.50  0.54  0.10  0.06  0.05  0.13  0.05  0.00  7.70  0.30
 10.2   0.2 23.80       19.07                                           7.70        7.70
 11.1   0.2 23.70 10.00 23.28  0.34  0.10  0.07  0.05  0.11  0.07  2.53  8.00
 12.1   0.2 24.10       15.96                                           8.30        7.80
 13.1   0.3 24.10 10.00 21.28  0.35  0.10  0.09  0.05  0.13  0.05  2.75  8.40
 14.2   0.3 24.40       23.06                                           9.00        7.90
 15.1   0.3 24.80  9.00 24.16  0.53  0.10  0.06  0.05  0.11  0.07  2.43 10.00
```

```
                 AQUIA CREEK INTENSIVE DATA (CORRECTED).

      D M Y= 24  8 81 STN = 00002 BOTTOM DEPTH =  2.00,CRUISE= AQ881,RIVER= AQ,
TIME  SEC   TEMP   TOC CHLOR ORG-N NH3-N N2-N3   NO3 ORG-P INO-P  BODU    DO   DYE    PH
      CHI              PHYLL                   N     N
      DISK   (C)(MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

13.1  0.3  24.20 11.00 20.84  0.45  0.10  0.06  0.05  0.13  0.05  3.91  9.90  0.30
14.3  0.3  23.80       15.30                                           12.00
15.2  0.3  23.70 10.00 21.73  0.55  0.10  0.06  0.05  0.13  0.05  7.84  8.90
16.2  0.3  24.50       20.17                                            9.80
17.2  0.3  24.50 12.00 19.73  0.46  0.10  0.06  0.05  0.14  0.04  8.07  8.90
18.3  0.3  24.70       23.94                                            8.00
19.2  0.2  23.70 11.00 19.73  0.46  0.10  0.06  0.05  0.13  0.05  2.41  7.10
20.1  0.0  24.30       13.08                                            8.00
21.3  0.0  24.50 11.00 20.17  0.56  0.10  0.06  0.05  0.14  0.04  5.45  9.10  0.30
22.3  0.0  24.10       13.30                                            8.10
23.2  0.0  23.70 10.00 14.19  0.50  0.10  0.07  0.05  0.12  0.07  3.55  8.20
```

AQUIA CREEK INTENSIVE DATA (CORRECTED).

```
       D M Y= 25  8 81 STN = 00002 BOTTOM DEPTH =   2.00,CRUISE= AQ881,RIVER= AQ,
TIME  SEC  TEMP   TOC  CHLOR ORG-N NH3-N N2-N3  NO3  ORG-P INO-P BODU  DO    DYE    PH
      CHI              PHYLL               N     N
     DISK   (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

 0.2  0.0  23.70       17.29                                            7.90
 1.5  0.0  23.40  3.10  9.75  0.33  0.10  0.15  0.10  0.11  0.08  2.25  7.30
 2.3  0.0  23.30        7.09                                            7.20
 3.4  0.0  23.10 11.00 17.74  0.48  0.10  0.06  0.05  0.12  0.06  0.58  7.90
 4.2  0.0  23.30       17.74                                            7.90
 5.2  0.0  20.80 10.00 20.62  0.46  0.10  0.06  0.05  0.13  0.05  2.83  7.90
 6.0  0.0  23.20       23.50                                            7.70
 7.2  0.0  20.50 11.00 25.05  0.52  0.10  0.06  0.05  0.12  0.05  2.33  7.60
 8.2  0.3  22.70       24.39                                            7.90        7.80
 9.3  0.2  20.90 11.00 26.60  0.51  0.10  0.06  0.05  0.02  0.05  2.16  8.20
10.3  0.2  23.20       23.72                                            8.00        8.00
11.3  0.2  21.30 11.00 23.50  0.44  0.10  0.06  0.05  0.03  0.05  2.50  8.00  0.30
12.3  0.2  23.90       27.05                                            8.30        7.70
13.3  0.2  24.10 11.00 25.05  0.32  0.10  0.06  0.05  0.13  0.04  2.33  8.50  0.30
14.3  0.2  24.20       23.50                                            8.90        8.00
15.2  0.2  24.50 13.00 28.38  0.40  0.10  0.06  0.05  0.01  0.06  4.53  9.60
```

23.0	0.0	23.40	12.00	21.50	0.55	0.10	0.06	0.05	0.04	0.04	5.30	8.50	1.35

AQUIA CREEK INTENSIVE DATA (CORRECTED).

D M Y= 24 8 81 STN = 00003 BOTTOM DEPTH = 1.00,CRUISE= AQ881,RIVER= AQ,

TIME	SEC CHI DISK	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	ORG-N (MG/L)	NH3-N (MG/L)	N2-N3 N (MG/L)	NO3 N (MG/L)	ORG-P (MG/L)	INO-P (MG/L)	BODU (MG/L)	DO (MG/L)	DYE (PPB)	PH
13.0	0.4	32.00	13.00	26.60	0.51	0.10	0.06	0.05	0.12	0.05	2.41	7.10	0.03	9.80
14.0	0.4	32.00		15.96								10.40	0.03	9.80
15.0	4.0	32.00	11.00	31.04	0.38	0.10	0.06	0.05	0.02	0.05	4.23	11.00	0.02	9.80
16.0	0.4	32.40		29.49								9.80	0.02	9.80
17.0	0.4	23.10	12.00	28.60	0.50	0.10	0.06	0.05	0.02	0.05	7.07	8.90	0.02	9.80
18.0	0.4	23.00		30.15								7.10	0.02	9.70
19.0	0.3	24.00	13.00	28.38	0.50	0.10	0.06	0.05	0.03	0.04	3.96	7.10	0.70	8.90
19.9	0.0	24.10		25.72								8.50	3.40	
21.0	0.0	23.90	16.00	27.05	0.51	0.10	0.06	0.05	0.02	0.05	7.25	9.00	3.50	
21.9	0.0	23.30		25.27								8.80	0.70	
23.0	0.0	23.40	12.00	21.50	0.55	0.10	0.06	0.05	0.04	0.04	5.30	8.50	1.35	

```
                    AQUIA CREEK INTENSIVE DATA (CORRECTED).

        D M Y= 25  8 81 STN = 00003 BOTTOM DEPTH =  1.00,CRUISE= AQ881,RIVER= AQ,
TIME  SEC  TEMP   TOC  CHLOR ORG-N NH3-N N2-N3  NO3  ORG-P INO-P BODU   DO   DYE    PH
      CHI              PHYLL                N     N
      DISK  (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

 0.0  0.0  23.40                                                      8.40  1.05
 1.0  0.0  23.40 13.00 24.16  0.43  0.10  0.06  0.05  0.04  0.04  3.66  8.10  0.04
 2.0  0.0  23.30       23.50                                          8.00  0.05
 3.0  0.0  23.00 12.00 20.40  0.46  0.10  0.06  0.05  0.03  0.05  2.85  7.60  0.07
 4.1  0.0  24.90       27.49                                          7.50  0.91
 5.2  0.0  22.30 11.00 24.61  0.53  0.10  0.06  0.05  0.03  0.05  4.95  7.20  0.73
 6.0  0.4  22.30       26.16                                          6.70  0.58  7.50
 7.0  0.3  22.30 12.00 31.48  0.38  0.10  0.06  0.05  0.02  0.05  1.61  7.20  1.80  7.30
 8.0  0.3  23.20       26.60                                          7.30  2.01  7.40
 9.0  0.3  23.70 12.00 30.15  0.49  0.10  0.06  0.05  0.02  0.05  4.33  7.60  1.60  7.90
10.0  0.3  23.90       31.92                                          8.20  2.10  8.30
11.0  0.3  24.20 12.00 25.27  0.52  0.10  0.06  0.05  0.03  0.05  7.45  8.70  1.60  8.70
12.0  0.3  24.25       30.82                                          8.50  0.89  8.90
13.0  0.3  24.50 13.00 31.04  0.38  0.10  0.06  0.05  0.04  0.03  4.23  9.00  0.78  9.30
14.0  0.3  24.65       20.62                                          8.30  0.82  9.40
15.0  0.3  24.75 13.00 26.60  0.51  0.10  0.06  0.05  0.02  0.05  4.73  9.70  3.30  9.70
```

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                        AQUIA CREEK INTENSIVE DATA (CORRECTED).

       D M Y= 24  8 81 STN = 00004 BOTTOM DEPTH =  2.00,CRUISE= AQ881,RIVER= AQ,
TIME  SEC  TEMP   TOC  CHLOR ORG-N NH3-N N2-N3  NO3  ORG-P INO-P BODU   DO    DYE    PH
      CHI              PHYLL               N     N
     DISK   (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

13.3  0.4  32.00 14.00 31.92  0.38  0.10  0.06  0.05  0.03  0.04  3.57  9.60  0.02  8.70
14.1  0.4  32.00       27.27                                           10.20  0.04  9.50
15.1  0.3  32.00 13.00 22.17  0.44  0.10  0.06  0.05  0.04  0.04  7.79 11.00  1.25  9.50
16.1  0.4  32.00       25.49                                            9.80  1.62  9.40
17.1  0.4  24.80 12.00 28.38  0.30  0.10  0.06  0.05  0.03  0.04  7.10  8.80  1.60  9.90
18.0  0.3  24.90       25.27                                            9.10  1.45  9.30
19.0  0.3  24.50 13.00 25.27  0.42  0.10  0.06  0.05  0.13  0.04  4.88  9.20  0.27  7.90
20.1  0.0  24.40       19.73                                            8.80  0.20
21.1  0.0  23.60 12.00 20.17  0.46  0.10  0.06  0.05  0.04  0.04  8.02  8.70  0.79
22.0  0.0  24.30                                                        8.80  1.60
23.1  0.0  24.30 13.00 25.05  0.52  0.10  0.06  0.05  0.03  0.04  4.90  9.10  5.00
```

AQUIA CREEK INTENSIVE DATA (CORRECTED).

D M Y= 25 8 81 STN = 00004 BOTTOM DEPTH = 2.00,CRUISE= AQ881,RIVER= AQ,

TIME	SEC CHI DISK	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	ORG-N (MG/L)	NH3-N (MG/L)	N2-N3 N (MG/L)	NO3 N (MG/L)	ORG-P (MG/L)	INO-P (MG/L)	BODU (MG/L)	DO (MG/L)	DYE (PPB)	PH
0.2	0.0	23.80		27.93								8.50	4.20	
1.2	0.0	23.50	13.00	26.60	0.51	0.10	0.06	0.05	0.03	0.04	3.78	7.80	2.50	
2.1	0.0	23.40		25.05								7.70	2.10	
3.2	0.0	23.30	13.00	25.72	0.42	0.10	0.06	0.05	0.02	0.05	2.26	7.70	3.60	
4.2	0.0	23.40										7.70	3.80	
5.2	0.0	23.00	12.00	22.61	0.44	0.10	0.06	0.05	0.03	0.05	5.17	6.80	1.15	
6.2	0.3	23.00		26.16								6.70	1.40	7.40
7.1	0.2	23.00	11.00	28.82	0.40	0.10	0.06	0.05	0.04	0.03	4.48	6.60	2.80	7.30
8.2	0.0	23.25		23.06								6.90	2.10	7.30
9.2	0.2	23.40	15.00	28.16	0.40	0.10	0.06	0.05	0.04	0.03	4.55	7.80	3.60	7.50
10.2	0.3	23.60		28.16								7.10	3.30	7.30
11.2	0.3	24.30	13.00	26.38	0.42	0.10	0.06	0.05	0.04	0.03	4.75	8.00	1.10	7.90
12.2	0.2	24.20		24.61								8.20	2.10	7.70
13.2	0.2	24.90	13.00	24.39	0.43	0.10	0.06	0.05	0.05	0.03	10.11	9.20	2.90	8.90
15.1	0.2	24.80		29.71								8.80	3.10	8.90
15.1	0.2	24.90	12.00	30.59	0.49	0.10	0.06	0.05	0.04	0.03	6.85	9.80	1.90	9.70

AQUIA CREEK INTENSIVE DATA (CORRECTED).

D M Y= 24 8 81 STN = 00005 BOTTOM DEPTH = 2.00,CRUISE= AQ881,RIVER= AQ,

TIME	SEC CHI DISK	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	ORG-N (MG/L)	NH3-N (MG/L)	N2-N3 N (MG/L)	NO3 N (MG/L)	ORG-P (MG/L)	INO-P (MG/L)	BODU (MG/L)	DO (MG/L)	DYE (PPB)	PH
13.5	0.4	32.00	14.00	27.27	0.41	0.10	0.06	0.05	0.02	0.05	5.24	9.30	0.03	9.30
14.2	0.3	32.00		21.95								10.20	0.03	9.00
15.3	0.3	32.00	12.00	27.05	0.41	0.10	0.06	0.05	0.03	0.04	7.25	8.80	0.03	9.00
16.2	0.0	24.80		22.39								8.60	0.03	8.70
17.2	0.4	24.50	11.00	23.28	0.44	0.10	0.06	0.05	0.04	0.04	7.67	8.60	0.02	7.30
18.1	0.3	24.30		29.33								8.70	0.02	7.40
19.2	0.2	24.10	13.00	16.41	0.39	0.10	0.06	0.05	0.04	0.04	4.58	8.20	0.03	7.50
20.2	0.0	24.10		25.05								8.20	0.03	
21.2	0.0	24.00	12.00		0.33	0.10	0.06	0.05	0.03	0.05	4.98	7.70	0.04	
22.1	0.0	23.90		25.49								7.80	0.17	
23.3	0.0	23.70	13.00	25.05	0.32	0.10	0.06	0.05	0.02	0.05	4.90	7.80	0.23	

AQUIA CREEK INTENSIVE DATA (CORRECTED).

```
      D M Y= 25  8 81 STN = 00005 BOTTOM DEPTH =  2.00,CRUISE= AQ881,RIVER= AQ,
TIME   SEC  TEMP   TOC CHLOR ORG-N NH3-N N2-N3   NO3 ORG-P INO-P  BODU    DO   DYE    PH
       CHI             PHYLL                 N     N
      DISK   (C)(MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

  0.2  0.0 24.20       22.17                                            7.60  0.29
  1.3  0.0 23.40 13.00        0.45  0.10  0.06  0.05  0.04  0.04  5.76  7.20  6.60
  2.2  0.0 23.40       23.50                                                  0.27  7.30
  3.4  0.0 23.50 12.00 21.06  0.45  0.10  0.06  0.05  0.05  0.03  5.35  7.00  3.15
  4.3  0.0 23.50       22.39                                            6.70  1.65
  5.3  0.0 23.40 11.00 17.74  0.48  0.10  0.06  0.05  0.05  0.03  3.15  6.50  0.78
  6.4  0.2 23.30       20.62                                            6.20  0.53  7.20
  7.2  0.2 23.20 10.00 21.73  0.35  0.10  0.06  0.05  0.06  0.02  2.70  6.10  0.19  7.10
  8.3  0.3 23.20       23.50                                            6.00  0.07  7.30
  9.3  0.3 23.50 10.00 25.49  0.32  0.10  0.06  0.05  0.04  0.03  2.28  6.40  0.06  6.80
 10.3  0.3 23.85       20.84                                            7.10  0.13  7.00
 11.3  0.3 24.90 13.00 22.17  0.44  0.10  0.06  0.05  0.06  0.02  5.22  8.10  0.22  7.40
 12.3  0.2 25.25       23.50                                            8.60  1.60  7.50
 13.3  0.2 25.70 12.00        0.35  0.10  0.06  0.05  0.05  0.03  5.25  9.30  0.98  7.80
 14.2  0.2 25.90       21.06                                            9.50  1.15  7.80
 15.2  0.2 25.45 13.00 21.73  0.45  0.10  0.06  0.05  0.06  0.02  7.84  9.50        8.30
```

AQUIA CREEK INTENSIVE DATA (CORRECTED).

```
      D M Y= 24  8 81 STN = 00006 BOTTOM DEPTH =  2.00,CRUISE= AQ881,RIVER= AQ,
TIME  SEC  TEMP   TOC  CHLOR ORG-N NH3-N N2-N3  NO3  ORG-P INO-P BODU   DO   DYE    PH
      CHI              PHYLL               N     N
     DISK  (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

13.1  0.4 25.00 11.00 17.29  0.48  0.10  0.06  0.05  0.04  0.04  4.05  7.60  0.02  7.00
14.2  0.3 25.00       21.06                                             7.30        6.90
15.3  0.3 24.00 12.00 20.17  0.36  0.10  0.06  0.05  0.08        5.45  8.60
16.2  0.4 24.50       23.28                                             9.80  0.02  6.90
17.2  0.4 24.50 11.00 17.96  0.47  0.10  0.06  0.05  0.01  0.07  5.70  9.60
18.3  0.3 24.40       16.85                                             9.70        6.80
19.3  0.0 24.50 11.00 12.41  0.31  0.10  0.06  0.05  0.06  0.03  4.60  9.20
20.2  0.0 24.30       14.63                                             8.90
21.3  0.0 24.00 11.00 17.74  0.48  0.10  0.06  0.05  0.01  0.07  5.72  8.70
22.3  0.0 24.00                                                         8.60
23.3  0.0 23.80 13.00 19.29  0.46  0.10  0.06  0.05  0.05  0.03  5.55  8.40
```

AQUIA CREEK INTENSIVE DATA (CORRECTED).

```
      D M Y= 25  8 81  STN = 00006  BOTTOM DEPTH =  2.00,CRUISE= AQ881,RIVER= AQ,
TIME  SEC  TEMP   TOC  CHLOR ORG-N NH3-N N2-N3  NO3  ORG-P INO-P BODU   DO    DYE    PH
      CHI              PHYLL               N     N
     DISK  (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

 1.3  0.0 23.60 13.00 18.62  0.47  0.10  0.06  0.05  0.04  0.04  4.93  8.40  0.01
 2.4  0.0 24.00       11.97                                            8.10
 3.3  0.0 24.00 12.00 19.73  0.46  0.10  0.06  0.05  0.06  0.02  2.93  7.90  0.01
 4.2  0.0 24.00       18.62                                            7.50
 5.4  0.4 23.00 12.00 10.42  0.63  0.20  0.06  0.05  0.04  0.05  3.97  7.20
 6.4  0.4 22.90       21.28                                            6.80        6.80
 7.4  0.3 27.00 10.00 24.39  0.33  0.10  0.06  0.05  0.06  0.02  2.40  6.30  0.01  6.70
 8.4  0.4 23.00       23.94                                            5.90        6.70
10.3  0.5 24.10       23.94                                            6.30
11.5  0.3 25.30 10.00 28.38  0.40  0.10  0.06  0.05  0.04  0.03  1.96  7.80
12.4  0.3 24.60       24.61                                            7.90        6.80
13.4  0.3 24.60 12.00 23.94  0.33  0.10  0.06  0.05  0.06  0.02  5.03  7.90
14.2  0.1 24.70       27.05                                            8.10        6.70
15.3  0.4 24.50 11.00 29.26  0.40  0.10  0.06  0.05  0.05  0.02  4.43  7.90
```

AQUIA CREEK INTENSIVE DATA (CORRECTED).

```
       D M Y= 24  8 81 STN = 00007 BOTTOM DEPTH =  2.00,CRUISE= AQ881,RIVER= AQ,
TIME  SEC  TEMP   TOC  CHLOR ORG-N NH3-N N2-N3  NO3  ORG-P INO-P BODU   DO    DYE    PH
      CHI              PHYLL               N     N
     DISK   (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

13.0  0.6  25.30 12.00  9.75  0.33  0.10  0.06  0.05  0.07  0.02  6.10  8.80        6.70
14.0  0.5  25.50       20.40                                            7.60  0.02  6.90
15.0  0.5  26.00 11.00 13.97  0.30  0.10  0.06  0.05  0.07  0.02  6.14  5.20
16.1  0.5  23.10       12.41                                            5.10        6.90
17.0  0.5  23.00 11.00  8.87  0.34  0.10  0.06  0.05  0.07  0.02  6.72  6.50
18.1  0.5  22.20        6.21                                            6.20        7.00
19.1  0.0  22.70 12.00 11.97  0.32  0.10  0.06  0.05  0.07  0.02  4.65  6.60  0.01
20.0  0.0  22.80       10.86                                            6.80
21.0  0.0  23.00 10.00 11.31  0.32  0.10  0.06  0.05  0.07  0.02  6.44  5.70  0.01
22.0  0.0  22.50       11.53                                            5.50
23.0  0.0  22.20 11.00 13.08  0.31  0.10  0.06  0.05  0.07  0.02  3.67  6.30
```

AQUIA CREEK INTENSIVE DATA (CORRECTED).

```
         D M Y= 25   8 81 STN = 00007 BOTTOM DEPTH =   2.00,CRUISE= AQ881,RIVER= AQ,
 TIME   SEC  TEMP    TOC  CHLOR ORG-N NH3-N N2-N3  NO3  ORG-P INO-P BODU   DO    DYE    PH
        CHI               PHYLL             N     N
       DISK   (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

  1.0   0.0  22.50  9.00 13.52  0.41  0.10  0.06  0.05  0.06  0.03  3.32  6.60
  2.1   0.0  23.00       11.08                                           6.90
  3.0   0.0  24.00  9.00 11.75  0.42  0.10  0.06  0.05  0.07  0.02  3.82  7.30
  4.0   0.0  23.50       11.64                                           7.60
  5.0   0.5  22.60  9.00 10.86  0.32  0.10  0.06  0.05  0.08  0.01  3.92  6.20
  6.0   0.5  22.70       12.64                                           6.40         6.70
  7.1   0.6  22.90  9.00 15.96  0.29  0.10  0.06  0.05  0.06  0.02  3.35  4.10         6.70
  8.2   0.6  22.90       18.40                                           3.60         6.70
  9.1   0.6  23.50 10.00 17.07  0.28  0.10  0.06  0.05  0.06  0.02  0.66  6.30         6.70
 10.1   0.6  24.10       14.41                                           6.70         6.70
 11.2   0.6  24.60 10.00 17.74  0.28  0.10  0.06  0.05  0.06  0.02  5.72  7.30  0.01  6.70
 12.1   0.5  24.70       17.51                                           6.80         6.70
 13.1   0.5  24.60 10.00 17.96  0.27  0.10  0.06  0.05  0.06  0.02  5.70  6.90
 14.1   0.5  24.40       17.29                                           6.80         6.70
 15.1   0.5  24.20 10.00 13.52  0.31  0.10  0.06  0.05  0.07  0.02  6.19  7.00
```

AQUIA CREEK INTENSIVE DATA (CORRECTED).

D M Y= 24 8 81 STN = 00008 BOTTOM DEPTH = 0.00,CRUISE= AQ881,RIVER= AQ,

TIME	SEC CHI DISK	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	ORG-N (MG/L)	NH3-N (MG/L)	N2-N3 N (MG/L)	NO3 N (MG/L)	ORG-P (MG/L)	INO-P (MG/L)	BODU (MG/L)	DO (MG/L)	DYE (PPB)	PH
13.1	0.0	20.50	6.00	0.33	0.20	0.20	0.19	0.18	0.09	0.01	1.89	9.40		6.70
14.1	0.0	21.20		0.49								11.50		7.20
15.1	0.0	21.10	5.00	0.53	0.30	0.10	0.22	0.21	0.09	0.01	2.51	9.60		7.20
16.1	0.0	22.00		0.73								9.90		7.20
17.1	0.0	21.90	6.00	0.53	0.30	0.20	0.22	0.21	0.09	0.01	2.51	10.70		7.20
18.1	0.0	23.80		0.44								11.00		7.20
19.1	0.0	28.00	5.00	0.11	0.20	0.20	0.19	0.18	0.09	0.01	2.04	10.60		
20.1	0.0	24.00		0.53								11.00		
21.2	0.0	22.40	6.00	0.64	0.30	0.20	0.22	0.21	0.09	0.01	2.50	9.80		
22.1	0.0	21.80		0.27								9.30		
23.1	0.0	21.20	5.00	0.75	0.19	0.20	0.21	0.20	0.09	0.01	2.49	9.00		

AQUIA CREEK INTENSIVE DATA (CORRECTED).

```
       D M Y= 25   8 81 STN = 00008 BOTTOM DEPTH =   0.00,CRUISE= AQ881,RIVER= AQ,
TIME  SEC  TEMP   TOC  CHLOR ORG-N NH3-N N2-N3  NO3  ORG-P INO-P BODU   DO    DYE    PH
      CHI              PHYLL              N     N
     DISK   (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

 0.1  0.0  21.60        0.64                                            9.00
 1.1  0.0  21.30  6.00  0.53  0.20  0.20  0.22  0.21  0.09  0.01  1.61  8.70
 2.1  0.0  20.90                                                        8.10
 3.2  0.0  21.00  4.00  0.80  0.39  0.20  0.22  0.21  0.09  0.01  2.48  7.00
 4.2  0.0  21.00        0.42                                            7.90
 5.1  0.0  20.50  8.00  1.77  0.29  0.20  0.22  0.21  0.09  0.01  2.37  7.60
 6.1  0.0  20.80        0.75                                            7.00
 7.2  0.0  20.20  5.00  1.77        0.20  0.23  0.22  0.09  0.01  2.37  7.00        7.00
 8.1  0.0               2.26                                            6.80        7.00
 9.1  0.0  20.50  5.00  2.26  0.08  0.10  0.06  0.05  0.09  0.01  2.32  6.80        7.00
10.1  0.0  21.00        2.79                                            7.60        7.00
11.3  0.0  23.00  6.00  5.76  0.66  0.30  0.22  0.21  0.08  0.01  4.49  7.40        7.00
12.0  0.0  22.80        2.77                                            8.60        7.00
13.1  0.0  22.50  5.00  1.00  0.09  0.20  0.22  0.21  0.09  0.01  2.46  8.30        7.00
14.1  0.0  23.20       10.64                                            9.50        7.10
15.1  0.0         9.70  1.20  0.39  0.20  0.23  0.22  0.09  0.01  2.44  9.70        7.00
```

AQUIA CREEK INTENSIVE DATA (CORRECTED).

```
       D M Y= 24   8 81 STN = 00009 BOTTOM DEPTH =   0.00,CRUISE= AQ881,RIVER= AQ,
TIME  SEC  TEMP   TOC  CHLOR ORG-N NH3-N N2-N3  NO3  ORG-P INO-P BODU   DO    DYE    PH
      CHI              PHYLL              N     N
     DISK   (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

15.0  0.0  22.40 16.00        3.30  9.00  0.27  0.21  0.09  5.00  4.25  6.30        7.50
15.0  0.0  22.90 19.00        3.60  9.00  0.22  0.18  0.09  5.00  6.12  6.30        7.50
```

```
                      AQUIA CREEK INTENSIVE DATA (CORRECTED).

        D M Y= 25   8 81 STN = 00009 BOTTOM DEPTH =  0.00,CRUISE= AQ881,RIVER= AQ,
TIME   SEC  TEMP   TOC  CHLOR ORG-N NH3-N N2-N3  NO3  ORG-P INO-P BODU   DO    DYE    PH
       CHI               PHYLL              N     N
      DISK   (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

 0.3   0.0  21.30 21.00        3.40  9.50  0.20  0.15  0.39  5.00  4.89  6.30
15.0   0.0  22.00 17.00        3.10 10.00  0.20  0.15  0.19  5.00  4.38  6.40        7.20



                      AQUIA CREEK INTENSIVE DATA (CORRECTED).

        D M Y= 24   8 81 STN = 00010 BOTTOM DEPTH =  0.00,CRUISE= AQ881,RIVER= AQ,
TIME   SEC  TEMP   TOC  CHLOR ORG-N NH3-N N2-N3  NO3  ORG-P INO-P BODU   DO    DYE    PH
       CHI               PHYLL              N     N
      DISK   (C) (MG/L)(UG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L)(MG/L) (PPB)

11.7   0.0         8.00        0.00  0.10  0.06  0.05  0.09  0.01  2.52
13.4   0.0  20.00  5.00  0.27  0.10  0.10  0.06  0.05  0.09  0.01  2.03  9.40        7.20
14.3   0.0  19.10  5.00  0.53  0.00  0.10  0.06  0.05  0.09  0.01  2.51  8.90        7.20
15.4   0.0  20.00  5.00  0.64  0.00  0.10  0.06  0.05  0.09  0.01  2.50  8.90        7.20
16.3   0.0  20.80        0.13                                             8.70        6.70
17.3   0.0  20.40  6.00  0.29  0.10  0.10  0.06  0.05  0.09  0.01  2.54  8.50        6.70
18.3   0.0  20.20        0.29                                             8.50        6.70
19.3   0.0  20.90  6.00  0.55  0.10  0.10  0.06  0.05  0.07  0.03  1.74  8.00
20.3   0.0  20.20        0.80                                             8.00
21.4   0.0  20.10  8.00  0.44  0.20  0.10  0.06  0.05  0.04  0.06  2.52  7.80
22.3   0.0  20.00        0.24                                             7.80
23.3   0.0  19.90  6.00  0.62  0.20  0.20  0.06  0.05  0.04  0.16  2.50  7.90
```

AQUIA CREEK INTENSIVE DATA (CORRECTED).

D M Y= 25 8 81 STN = 00010 BOTTOM DEPTH = 0.00,CRUISE= AQ881,RIVER= AQ,

TIME	SEC CHI DISK	TEMP (C)	TOC (MG/L)	CHLOR PHYLL (UG/L)	ORG-N (MG/L)	NH3-N (MG/L)	N2-N3 N (MG/L)	NO3 N (MG/L)	ORG-P (MG/L)	INO-P (MG/L)	BODU (MG/L)	DO (MG/L)	DYE (PPB)	PH
0.3	0.0	19.80		0.33								8.00		
1.4	0.0	19.60	5.00	0.73	0.09	0.10	0.06	0.05	0.06	0.04	1.79	7.80		
2.3	0.0	19.30		0.62								7.90		
3.4	0.0	19.10	5.00	0.49	0.00	0.10	0.06	0.05	0.08	0.02	2.52	8.10		
4.3	0.0	19.00		0.69								7.90		
5.3	0.0	18.80	6.00	0.89	0.00	0.10	0.06	0.05	0.09	0.01	2.47	8.10		
6.2	0.0	18.30		0.35								8.00		
7.3	0.0	18.30	5.00	1.33	0.00	0.10	0.06	0.05	0.09	0.01	2.42	8.40		7.10
8.3	0.0	18.60		1.24								8.30		7.10
9.3	0.0	19.10	5.00	1.40	0.19	0.30	0.06	0.05	0.09	0.01	2.41	8.60		7.10
10.2	0.0	19.90		1.06								8.00		7.10
11.4	0.0	20.50	6.00	0.98	0.09	0.10	0.06	0.05	0.09	0.01	2.46	8.60		7.30
12.2	0.0	21.10		1.64								8.60		7.40
13.3	0.0	21.10	5.00	0.75	0.09	0.10	0.06	0.05	0.09	0.01	2.49	8.50		7.20
14.2	0.0	20.90		1.17								8.40		7.10
15.3	0.0	21.20	6.00	1.75	0.00	0.10	0.06	0.05	0.09	0.01	2.37	8.50		7.20

Appendix C. Nonpoint Source Loadings

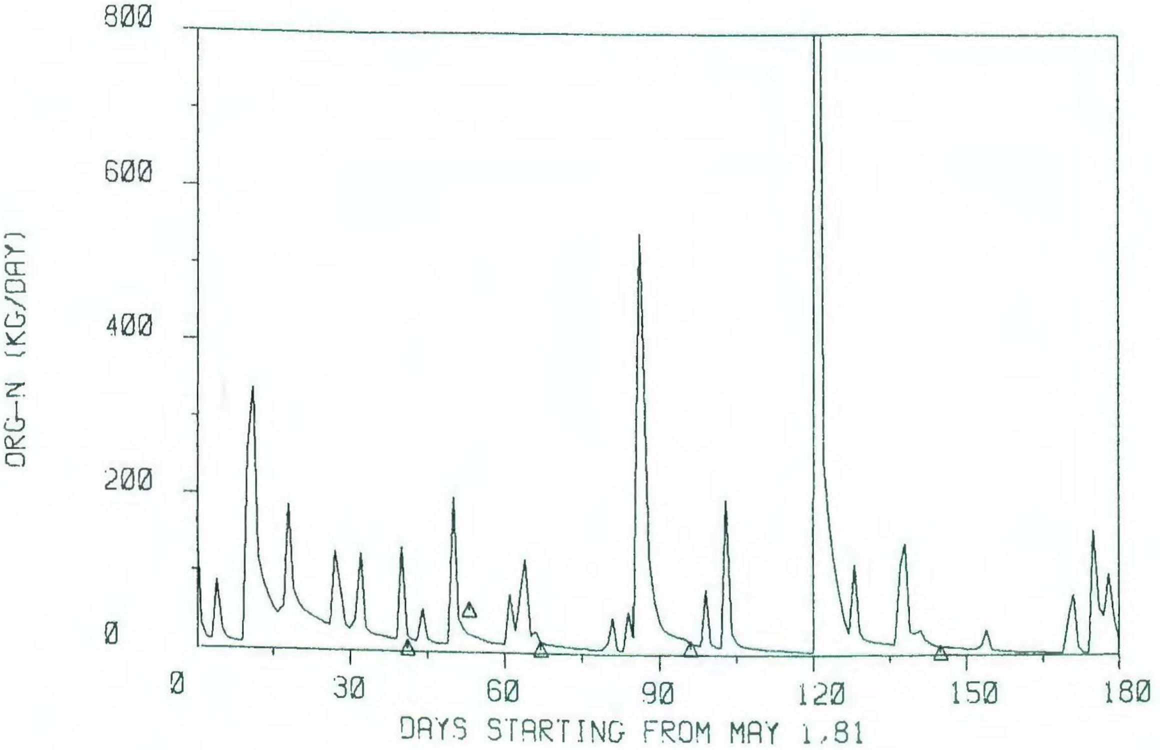

FIGURE AQUIA CREEK NONPOINT SOURCE LOADINGS.

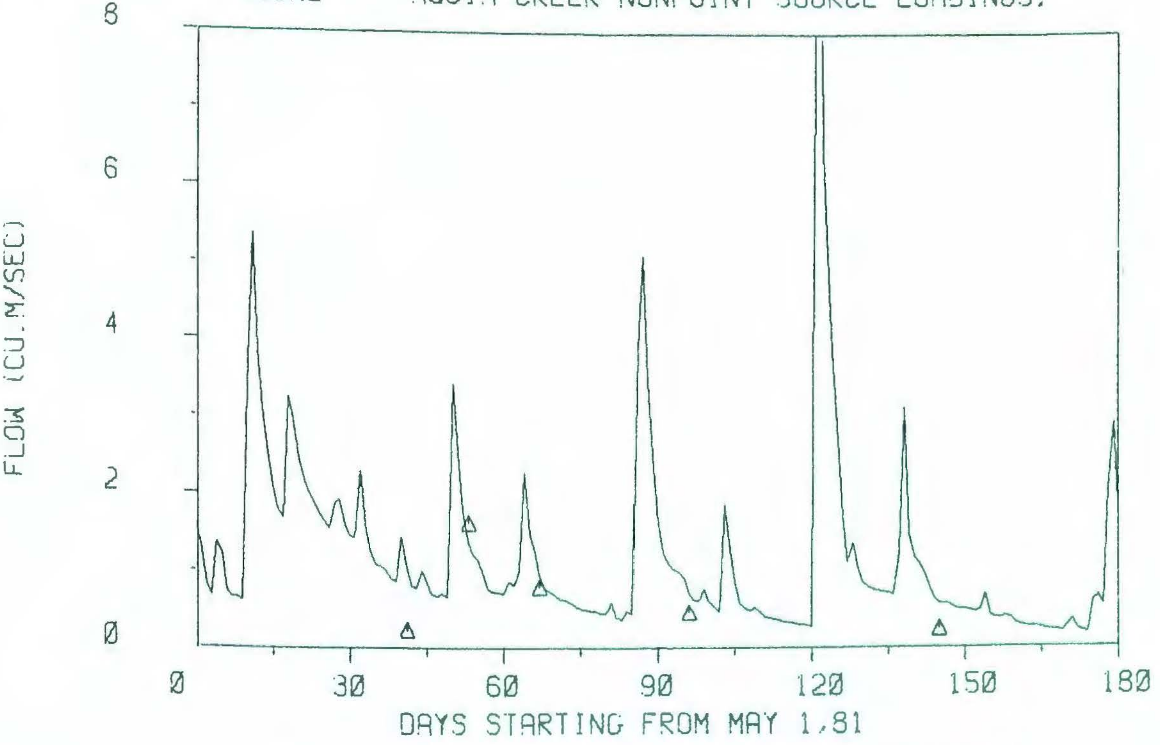

FIGURE AQUIA CREEK NONPOINT SOURCE LOADINGS.

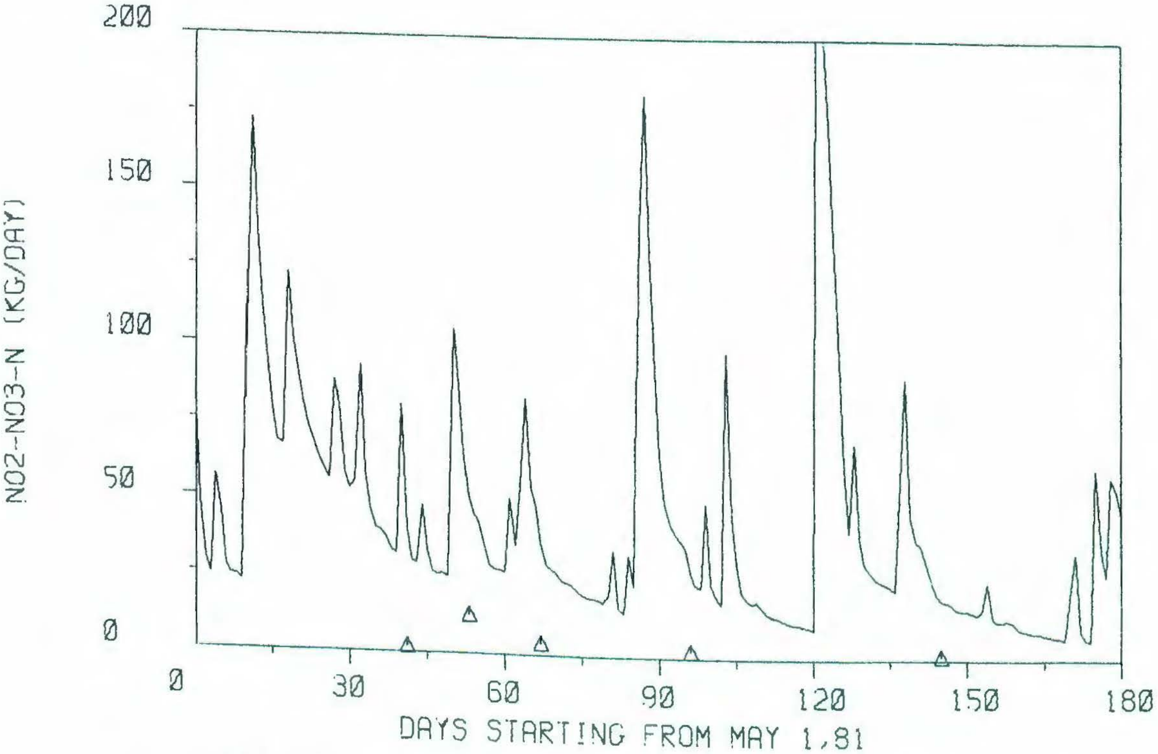

FIGURE AQUIA CREEK NONPOINT SOURCE LOADINGS.

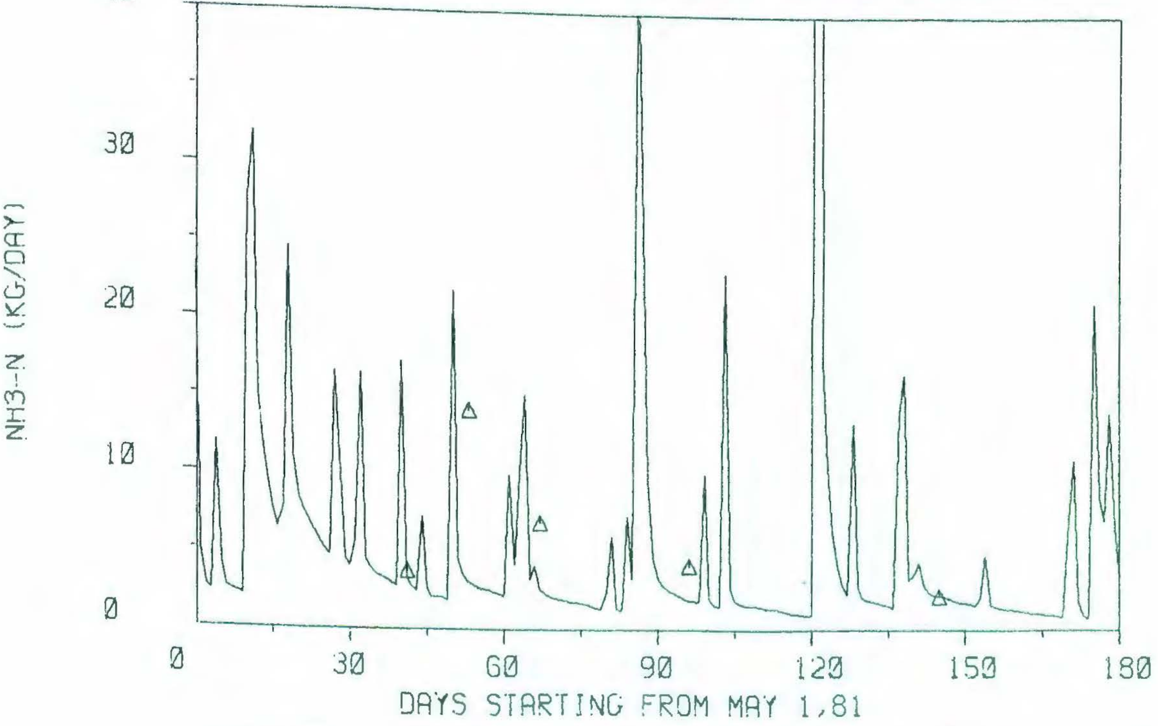

FIGURE AQUIA CREEK NONPOINT SOURCE LOADINGS.

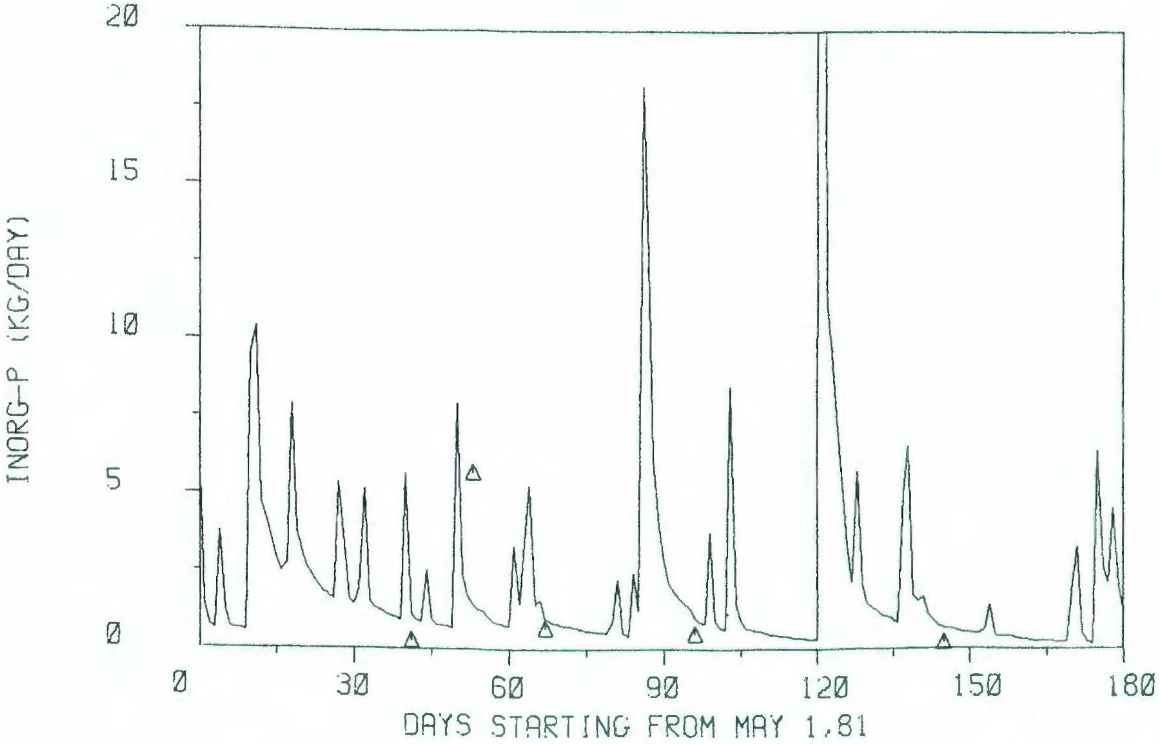

FIGURE AQUIA CREEK NONPOINT SOURCE LOADINGS.

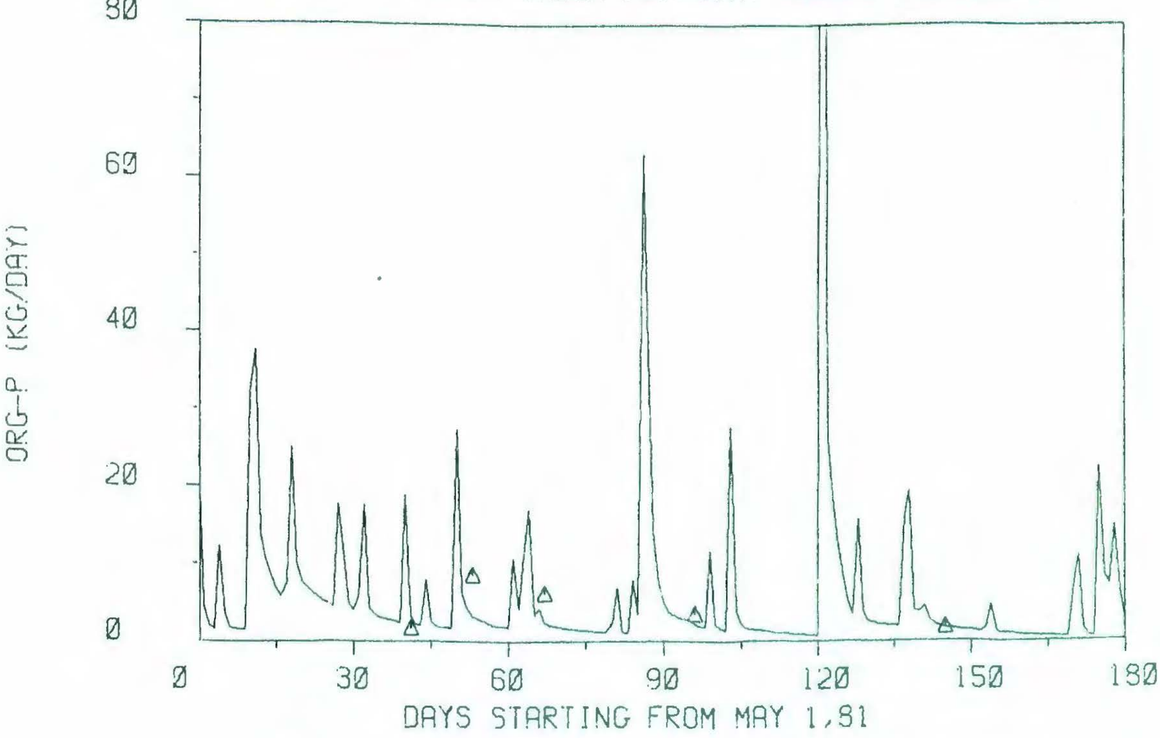

FIGURE AQUIA CREEK NONPOINT SOURCE LOADINGS.

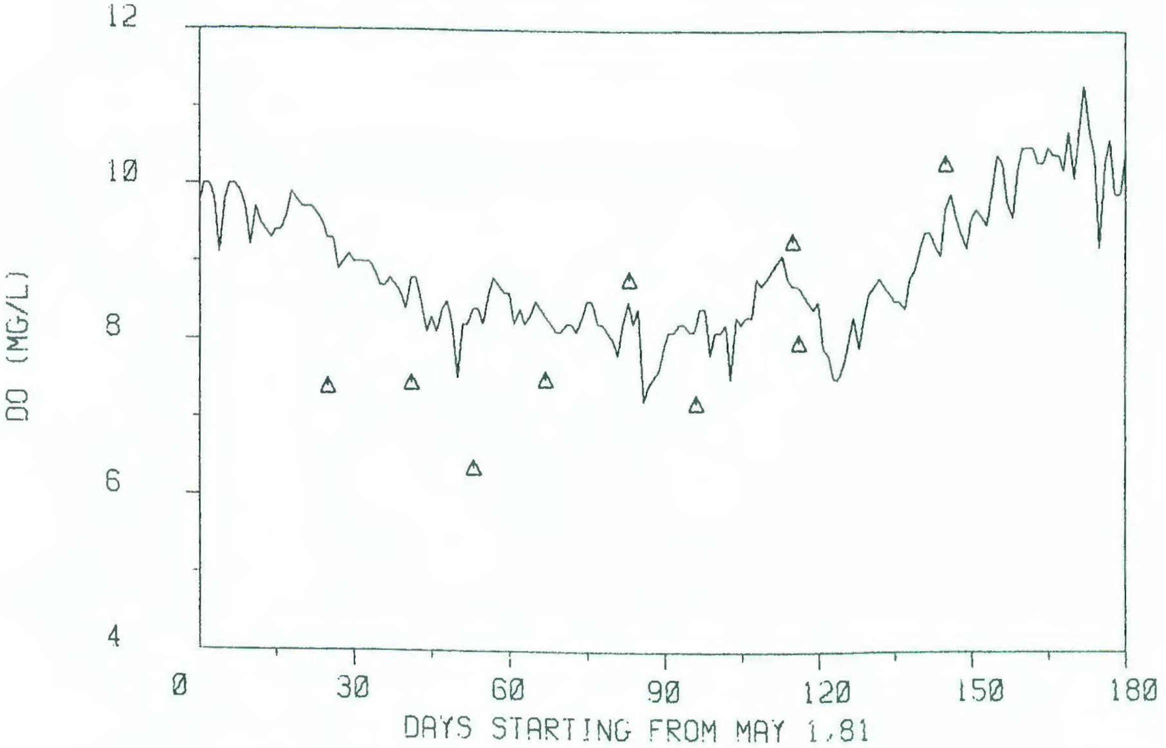

FIGURE AQUIA CREEK NONPOINT SOURCE LOADINGS.

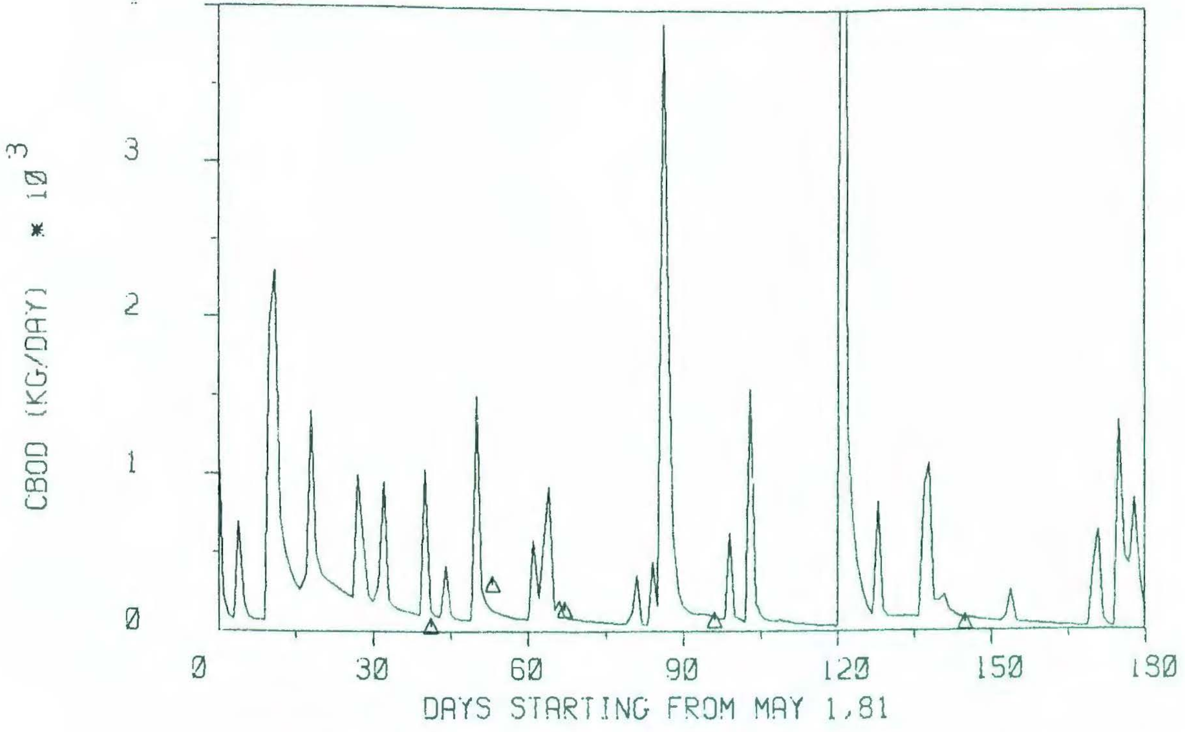

FIGURE AQUIA CREEK NONPOINT SOURCE LOADINGS.

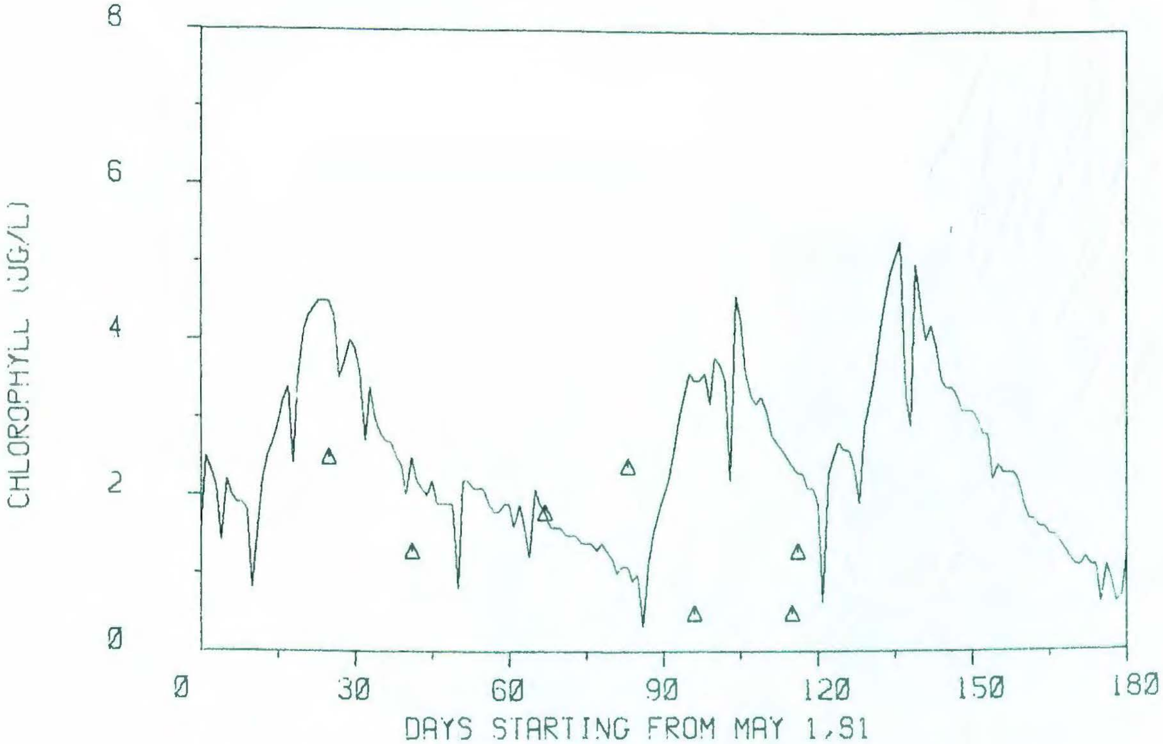

FIGURE AQUIA CREEK NONPOINT SOURCE LOADINGS.